DO NOT REMOVE FROM LIBRARY

AMERICAN SOCIETY

OF

CIVIL ENGINEERS

January, 1901

PROCEEDINGS = VOL. XXVII—No. 1

Published at the House of the Society, 220 West Fifty-seventh Street, New York, the Fourth Wednesday of each Month, except June and July.

Copyrighted, 1901, by the American Society of Civil Engineers.
Entered as Second-Class Matter at the New York City Post Office, December 15th, 1896.

Vol. XXVII. JANUARY, 1901. No. 1.

PROCEEDINGS

OF THE

AMERICAN SOCIETY OF CIVIL ENGINEERS.

Edited by the Secretary, under the direction of the Committee on Publications.

CONTENTS.

SOCIETY AFFAIRS.

PAGE.

Minutes of Meetings:
Of the Society, January 2d, 1901 1
Of the Board of Direction, December 28th, 1900 3
Announcements:
Hours during which the Society House is open 4
Meetings 4
Annual Convention 4
Annual Reports:
Of the Board of Direction 5
Of the Secretary 10
Of the Treasurer 14
Recent Engineering Articles of Interest 15
New Books of the Month 21
Donations to the Library 22
Membership (Additions) 23

PAPERS AND DISCUSSIONS.

Paper to be presented:

Flow in the Sewers of the North Metropolitan Sewerage System of Massachusetts.
By THEODORE HORTON, Assoc. M. Am. Soc. C. E. 2

Discussions on Papers which have been presented:

The Preservation of Railway Ties in Europe.
By Messrs. WARD BALDWIN and H. J. HOWE 11

The Theory and Practice of Precise Leveling.
By Messrs. W. S. WILLIAMS, J. A. OCKERSON and C. L. CRANDALL 13

Some Peculiar Railroad Bridge Accidents.
By JOSEPH MAYER, M. Am. Soc. C. E. 22

The Practical Column under Central or Eccentric Loads.
By ALBERT I. FRYE, M. Am. Soc. C. E. 23

The Kinzua Viaduct of the Erie Railroad Company.
By Messrs. GEORGE S. MORISON, R. S. BUCK and L. S. MOISSEIFF 27

A Direct Method of Spacing Rivets and Finding the Position, Etc., of Stiffeners in Plate Girders.
By Messrs. BERNT BERGER and F. W. SKINNER 39

The prices of publications are as follows: *Proceedings*, $6 per annum; *Transactions*, $10 per annum. Postage will be added when *Proceedings* are sent to foreign countries.

American Society of Civil Engineers.

OFFICERS FOR 1901.

President, J. JAMES R. CROES.

Vice-Presidents.

Term expires January, 1902:
RUDOLPH HERING,
ALFRED NOBLE,

Term expires January, 1903:
HENRY S. HAINES,
GEORGE H. BENZENBERG.

Secretary, CHARLES WARREN HUNT.

Treasurer, JOSEPH M. KNAP.

Directors.

Term expires January, 1902:	*Term expires January, 1903:*	*Term expires January, 1904:*
JOHN A. BENSEL,	JOHN F. O'ROURKE,	JOSIAH A. BRIGGS,
C. W. BUCHHOLZ,	HENRY B. SEAMAN,	GEORGE F. SWAIN.
SAMUEL WHINERY,	THOMAS H. JOHNSON,	EMIL KUICHLING,
EDMUND K. TURNER,	JOSEPH RAMSEY, JR.,	MORDECAI T. ENDICOTT.
PALMER C. RICKETTS,	HENRY B. RICHARDSON,	EDWARD C. CARTER,
JAMES D. SCHUYLER.	GEORGE A. QUINLAN.	FRANK C. OSBORN.

Assistant Secretary, T. J. McMINN.

Standing Committees.

THE PRESIDENT OF THE SOCIETY IS *ex-officio* MEMBER OF ALL COMMITTEES.

On Finance:	*On Publications:*	*On Library:*
SAMUEL WHINERY,	RUDOLPH HERING,	JOHN A. BENSEL,
C. W. BUCHHOLZ,	PALMER C. RICKETTS,	H. S. HAINES,
JOSIAH A. BRIGGS,	JOHN F. O'ROURKE,	M. T. ENDICOTT,
G. H. BENZENBERG,	JAMES D. SCHUYLER,	E. KUICHLING,
GEORGE F. SWAIN.	ALFRED NOBLE.	CHARLES WARREN HUNT.

Special Committees.

ON ANALYSIS OF IRON AND STEEL:—Sub-Committee of the American Society of Civil Engineers (of the International Committee on Standards for the Analysis of Iron and Steel, of which Prof. J. W. Langley is Chairman)—Charles B. Dudley, William Metcalf, Thomas Rodd.

ON UNITS OF MEASUREMENT:—George M. Bond, William M. Black, R. E. McMath, Charles B. Dudley, Alexander C. Humphreys.

ON THE PROPER MANIPULATION OF TESTS OF CEMENT:—George F. Swain, Alfred Noble, George S. Webster, W. B. W. Howe, Louis C. Sabin, H. W. York.

The House of the Society is open every day, except Sunday, from 9 A.M. to 10 P.M.

HOUSE OF THE SOCIETY—220 WEST FIFTY-SEVENTH STREET, NEW YORK.

TELEPHONE NUMBER, - - - 533 Columbus.
CABLE ADDRESS, - - - - "Ceas, New York."

Vol. XXVII. JANUARY, 1901. No. 1.

AMERICAN SOCIETY OF CIVIL ENGINEERS.

INSTITUTED 1852.

PROCEEDINGS.

NOTE.—This Society is not responsible, as a body, for the facts and opinions advanced in any of its publications.

SOCIETY AFFAIRS.

CONTENTS:

	PAGE
Minutes of Meetings:	
Of the Society, January 2d, 1901	1
Of the Board of Direction, December 28th, 1900	3
Announcements:	
Hours during which the Society House is open	4
Meetings	4
Annual Convention	4
Annual Reports:	
Of the Board of Direction	5
Of the Secretary	10
Of the Treasurer	14
Recent Engineering Articles of Interest	15
New Books of the Month	21
Donations to the Library	22
Membership (Additions)	23

MINUTES OF MEETINGS.

OF THE SOCIETY.

January 2d, 1901.—The meeting was called to order at 8.40 P. M., Vice-President Rudolph Hering in the chair; Charles Warren Hunt, Secretary; and present, also, 80 members and 14 guests.

The minutes of the meetings of December 5th and 19th, 1900, were approved, as printed in *Proceedings* for December, 1900.

A paper by C. R. Grimm, M. Am. Soc. C. E., entitled "The Kinzua Viaduct of the Erie Railroad Company," was presented by the Secretary, who also read a discussion by George S. Morison, M. Am. Soc. C. E.

The paper was also discussed by Messrs. R. S. Buck, H. A. La Chicotte, L. S. Moisseiff and C. W. Buchholz.

Ballots were canvassed, and the following candidates declared elected:

As Members.

Christian Andersen, Portland, Ore.
Robert Cooke Clarkson, Philadelphia, Pa.
Theophilus Michell, Trichinopoly, Madras, India.
Albert Lennox Richards, Rock Island, Ill.
Oliver Perry Sarle, Jr., Providence, R. I.
Caleb Mills Saville, Boston, Mass.
Frank Ellsworth Trask, Ontario, Cal.
Beverly Reid Value, New York City.

As Associate Members.

Alfred Carroll Bell, Minneapolis, Minn.
John Blodgett, Pittsburg, Pa.
James Henry Brace, Albany, N. Y.
Morton Burden, Youngstown, Ohio.
Burt Cole, Los Angeles, Cal.
Benjamin Curtis Donham, Seoul, Korea.
Walter Gordon Fox, Guayaquil, Equador.
James Madison Jackson, Parkersburg, W. Va.
Fred William Lepper, Chicago, Ill.
Alexis Joseph Malukoff, New York City.
Richard Morey, Kansas City, Mo.
Eugene Taylor Morrison, Harrisburg, Pa.
George Freeman Rowell, Pittsburg, Pa.
Henry Kent Seltzer, Kansas City, Mo.
Julian Thornley, New York City.
John Albert Vogleson, Sault Ste. Marie, Mich.
Wilbur Jay Watson, Cleveland, Ohio.
John T. Whistler, Washington, D. C.
William MacIntire White, Baltimore, Md.
Silas Woodard, Washington, D. C.

The Secretary announced the election, by the Board of Direction, on December 28th, 1900, of the following candidates:

As Associate.

Henry Coddington Meyer, Jr., New York City.

As Juniors.

Alexander Hamill, Jr., Jersey City, N. J.
Manuel de la Mora, Guadalajara, Mexico.
Eduardo Ortiz, Brooklyn, N. Y.
Seth Morton Van Loan, Catskill, N. Y.

The Secretary gave an outline of the programme for the Forty-eighth Annual Meeting.

Adjourned.

OF THE BOARD OF DIRECTION.

(Abstract.)

December 28th, 1900.—8.15 P. M.—Vice-President Hering in the chair; Charles Warren Hunt, Secretary, and present, also, Messrs. Bensel, Deyo, Knap, Manley, O'Rourke, Ricketts and Seaman.

A report was received from the Committee appointed to recommend the award of prizes for the year ending July, 1900, and the prizes were awarded by the Board, in accordance with the recommendations of the Committee, as follows:

The Norman Medal to James A. Seddon, M. Am. Soc. C. E., for his paper, entitled "River Hydraulics."

The Thomas Fitch Rowland Prize to Allen Hazen, M. Am. Soc. C. E., for his paper on "The Albany Water Filtration Plant."

The Collingwood Prize for Juniors to Robert P. Woods, Assoc. M. Am. Soc. C. E., for his paper on "Street Grades and Cross-Sections in Asphalt and Cement."

The appointment of the following Committee of Arrangements for the Annual Meeting was announced: Messrs. Joseph O. Osgood, R. S. Buck, Albert Carr and Charles Warren Hunt.

The following resignations were received and accepted:

EDWIN MITCHELL, Assoc. M. Am. Soc. C. E.

LOUIS D. FOUQUET, Jun. Am. Soc. C. E.

Applications were considered and other routine business transacted.

One candidate for Associate and four for Junior were elected.

Adjourned.

ANNOUNCEMENTS.

In accordance with the resolution of the Board of Direction, the House of the Society is open every day, except Sunday, from 9 A. M. to 10 P. M.

MEETINGS.

Wednesday, February 6th, 1901.—8.30 P. M.—A regular business meeting will be held. Ballots for membership will be canvassed, and a paper, entitled "The Adjustment of a Transit Survey as Compared with that of a Compass Survey," by Charles L. Crandall, M. Am. Soc. C. E., will be presented for discussion.

This paper was printed in the December, 1900, number of *Proceedings.*

Wednesday, February 20th, 1901.—8.30 P. M.—A regular meeting will be held, at which a paper, entitled "The Construction of Gravity Sand Filters at Nyack, N. Y.," by G. N. Houston, Assoc. M. Am. Soc. C. E., will be presented.

This paper was printed in the December, 1900, number of *Proceedings.*

Wednesday, March 6th, 1901.—8.30 P. M.—A regular meeting will be held. Ballots for membership will be canvassed, and a paper, entitled "Flow in the Sewers of the North Metropolitan Sewerage System of Massachusetts," by Theodore Horton, Assoc. M. Am. Soc. C. E., will be presented.

This paper is printed in this number of *Proceedings.*

ANNUAL CONVENTION OF 1901.

The Thirty-third Annual Convention of the Society will be held at Niagara Falls, N. Y., on Tuesday, Wednesday, Thursday and Friday, June 25th, 26th, 27th and 28th, 1901.

ANNUAL REPORT OF THE BOARD OF DIRECTION FOR THE YEAR ENDING DECEMBER 31st, 1900.

Presented at the Annual Meeting, January 16th, 1901.

The Board of Direction, in compliance with the Constitution of the Society, presents its report for the year ending December 31st, 1900.

Membership.

The changes in membership are shown in the following table: ‡

	Jan. 1st, 1900.			Jan. 1st, 1901.			Losses.				Additions.		Totals	
	Resident.	Non-Resident.	Total.	Resident.	Non-Resident.	Total.	Transfer.	Resignation.	Dropped.	Death.	Transfer.	Election.	Loss.	Gain.
Honorary Members	1	8	9	1	8	9	..	..	....	....	....	....	....	...
Corresponding Members	....	3	3	....	3	3	..	..	....	....	....	....	....	...
Members	257	1 113	1 370	280	1 140	1 420	..	3	5	21	*21	58	29	79
Associate Members	117	307	424	142	374	516	20	2	2	1	‡35	82	25	117
Associates	31	62	93	36	65	101	..	..	....	1	†2	7	1	9
Juniors	107	155	262	99	152	251	38	3	19	1	....	50	61	50
Fellows	12	26	38	9	28	37	..	..	....	1	....	....	1	...
Totals	525	1 674	2 199	567	1 770	2 337	58	8	26	25	58	197	117	255

*20 Associate Members and 1 Junior.

† Juniors.

‡ In tables heretofore published "Subscribers" were also given; these are omitted in the present table.

It will be seen by the table that the net increase during the year was 138, which is the largest annual increase in the history of the Society.

The total number of applications received during the year was 308.

Action taken by the Board has been as follows:

Passed to ballot as Members	87
Passed to ballot as Associate Members	126
Elected Associates	8
Elected Juniors	55
Total	276
Applications now awaiting action	61

The increase in the number of candidates defeated by ballot leads the Board to the belief that there is not a full understanding as to the care with which all applications are considered, and the weight which is always given to confidential communications in regard to any candidate. It is believed that whenever the use of a negative vote is justifiable, the candidate would not be passed to ballot if all available information were placed in the hands of the Board, and the fact that some of those who are defeated on the first ballot are again passed to a Reconsideration Ballot, and thereon elected, means either that the case against the applicant is not a good one, or that the Board has not been supplied with information on which a refusal to pass his name to ballot could be based. It is not intended to criticize in any way the exercise of the right of suffrage, but to express the belief that Members, generally, do not understand that the most certain and effectual manner in which to prevent the election of an undesirable candidate is to place in the hands of the Board the reasons which would impel them to cast a negative vote. If the monthly Blue Lists were carefully scanned, and each person connected with the Society would feel it his duty to give the Board the benefit of his knowledge of any applicant, it is confidently believed that better results would obtain, and that the special Reconsideration Ballot would be much less frequent and possibly disappear.

The losses by death reported during the year number 25. They are as follows:

Twenty-one Members: James Colwell Aldrich, William H. H. Benyaurd, Edward Arnold Correa, William Giddings Curtis, Frank Paul Davis, Bolton Waller DeCourcy, Edward Bates Dorsey, Norman Wilder Eayrs, George Dana Emerson, Ernest Grey Freeman, Bently Douglas Hasell, John MacLeod, James David Moffet, George H. Norman, Henry Wadsworth Reed, Marc John Reiseger, Fairman Rogers, Hamilton Smith, William Starling, Arthur Towne Thomas, Edward Higginson Williams.

One Associate Member: Dominik Lindenthal.

One Associate: Joseph Ruggles Richards.

One Junior: William White Seitzinger.

One Fellow: Collis P. Huntington.

Library.

The following sums have been expended during the year:

For binding 25 Volumes	$50.60
For purchase of books	21.50
	$72.10

The additions to the Library from all sources during the year have been as follows:

Bound Volumes	281
Unbound Volumes	359
Specifications	254
Maps, Photographs, Charts, etc.	127
	1 021

The total attendance registered in the Reading Room during the year was 1 784.

Since the last report of the Board the arduous work of reclassifying and indexing the Library, which has been in progress for more than two years, has been completed, and a Catalogue, a volume of 703 pages, covering 15 824 titles, which represent 32 788 volumes, pamphlets, maps, photographs, specifications, etc., has been printed and distributed to all persons connected with the Society.

The Board desires to emphasize the suggestion made in the circular issued with the Catalogue, that an effort on the part of each member would soon result in filling many of the incomplete sets of reports, etc., now on our shelves. The completion of the Index places the Library in a far better position than ever before, and it will now be possible by judicious purchase to secure many volumes which should be available for reference.

The Library Committee has made an estimate of the value of the Library, which appears in the statement of the assets of the Society.

Publications.

During the year the usual ten numbers of *Proceedings* and two volumes of *Transactions* have been published, but a comparison of the table given on page 4 with a similar table in the last Annual Report of the Board shows an increase in the number of pages and illustrations published.

The publications of the Society evidence a steady improvement in the character of the papers, thus increasing their value, both to the members and to the profession at large. The arduous editorial work on the *Transactions*, and the care with which the Library Catalogue has been prepared, reflect great credit upon the Secretary and his assistants.

Your Board has recently authorized the Secretary to prepare a general index to the forty-four volumes of *Transactions*, which it is hoped will be ready within the next few months.

Summary of Publications for 1900.

	Number issued.	Total edition of each Number.	Number of Pages.	Plates.	Cuts.
*Transactions**	2	2 600	1 152	76	305
*Proceedings**	10	2 750	1 529	50	257
Constitution and List of Members	1	2 800	212	....	....
Advertisements	10	2 700	143	....	....
Catalogue of Library	1	3 000	702	....	....
Totals	....	....	3 738	126	562

The cost of publications has been:

For Paper, Printing, Binding, etc., *Transactions* and *Proceedings*		$8 237.53
For Plates and Cuts		1 376.57
For Boxes, Mailing Lists, Copyright and sundry expenses		224.27
For Commission on Advertisements		322.48
For 7 400 copies of Papers and Memoirs		685.45
For List of Members		738.08
For Library Catalogue		3 221.39
Total		$14 805.77
For time of officers and clerks charged to Publications		3 379.26
Total		$18 185.03
Deduct amount received for advertisements	$2 221.25	
Deduct amount received for sale of publications	2 394.00	
		4 615.25
Net cost of publications		$13 569.78
Net cost of publications for 1899 (see Report of Board of Direction, January, 1900)		9 800.07

Meetings.

During the year 25 meetings have been held, as follows: At the Annual Meeting, 2; at the Annual Convention, 5; regular semi-monthly meetings, 18.

At these meetings 18 formal papers, 4 of which were illustrated with lantern slides, 4 topics for informal discussion, and 1 illustrated lecture, were presented.

The Thirty-second Annual Convention, held in the House of the

* Includes Indexes and Tables of Contents.

Institution of Civil Engineers, in London, was most successful. There were present at that meeting 68 members of the Society accompanied by 55 members of their families. The views of your Board in relation to this meeting were expressed in a recent communication to the Institution in the following words:

"Your cordial invitation to visit London, in a more or less organized body, during 1900, was accepted in the belief that a material and lasting benefit would be derived from the holding of a meeting of Engineers which would be International in character.

"The meeting of this Society, held in the home of the Parent Engineering Association of the World, brought together, for the exchange of professional views, a large number of engineers, comprising representatives from nine widely separated nations, and it is believed that the interest manifested, and the resulting technical discussions, fully justified the inauguration of such International Meetings."

Medals and Prizes.

The Norman Medal, for the year ending with the month of July, 1899, was awarded to E. Herbert Stone, M. Am. Soc. C. E., for his paper on "The Determination of Safe Working Stress for Railway Bridges of Wrought Iron and Steel."

The Thomas Fitch Rowland Prize, for the year ending with the month of July, 1899, was awarded to R. S. Buck, M. Am. Soc. C. E., for his paper, entitled "The Niagara Railway Arch."

The Collingwood Prize for Juniors, for the year ending with the month of July, 1899, was awarded to Julius Kahn, Jun. Am. Soc. C. E. (now Assoc. M. Am. Soc. C. E.), for his paper, entitled "The Coal Hoists of the Calumet and Hecla Mining Company."

Finances.

The financial affairs of the Society may be seen, from the reports of the Secretary and Treasurer, to be in excellent condition. It will be noticed that during the year, notwithstanding the additional expenses incident to the constantly increasing regular work, and the preparation and issue of the new "Catalogue of the Library," a payment of $10 000 on the principal of the mortgage indebtedness has been made.

In the last report of your Board a recommendation was made that a sum approximately equal to the amount of the Entrance Fees received each year be applied to the extinguishment of the debt.

The Entrance Fees received during the past year amounted to $4 905, and it is the intention to make a payment in 1901 of $5 000, thus reducing the debt to $70 000.

By order of the Board of Direction.

CHAS. WARREN HUNT,
Secretary.

New York. January 8th, 1901.

REPORT OF THE SECRETARY FOR THE

To the Board of Direction of the

Gentlemen,—I have the honor to present a statement of Re-
December 31st, 1900, to which is appended a table showing the com-
during the year, and its distribution to the several accounts. There is
affairs of the Society.

New York, January 9th, 1901.

Receipts.

Balance on hand December 31st, 1899, in Bank and Trust Company and in the hands of the Treasurer		$13 728.36
Entrance Fees	$4 905.00	
Current Dues	27 026.53	
Past Dues	1 428.01	
Advance Dues	9 528.03	
Certificates of Membership	201.57	
Badges	769.00	
Sales of Publications	2 394.00	
Advertisements	2 221.25	
Interest	112.76	
Compounding Dues	575.00	
Library	6.00	
Convention and Annual Meeting	984.00	
Binding	1 304.80	
Miscellaneous	39.33	
Historical Sketch	45.00	
		51 540.28
		$65 268.64

YEAR ENDING DECEMBER 31st, 1900.

American Society of Civil Engineers.

ceipts and Disbursements for the fiscal year of the Society, ending
pensation paid to persons who have been in the service of the Society
also presented a general balance sheet showing the condition of the

Respectfully submitted,

CHAS. WARREN HUNT,

Secretary.

Disbursements.

General Printing and Stationery	$1 404.12	
Publications	17 862.55	
Commission on Advertisements	322.48	
Postage	2 743.69	
Library	4 440.73	
Janitor	995.85	
Badges	684.00	
Contingencies	183.05	
Gas and Water	585.24	
Finance and Accounts	1 780.00	
House Supplies—Furniture	173.08	
Certificates of Membership	182.80	
Fuel	339.90	
Convention and Annual Meeting	2 017.89	
Insurance—Safe Deposit	6.00	
Medals and Prizes	182.81	
Interest and Taxes	3 437.00	
Current Business	6 489.01	
Repairs and Betterments	226.42	
Binding	1 282.20	
New Society House (Loan)	10 000.00	
		$55 338 82
Balance on hand December 31st, 1900		
In Garfield National Bank	$4 347.58	
In Union Trust Company	4 597.24	
In hands of Treasurer	985.00	
		9 929.82
		$65 268.64

GENERAL BALANCE SHEET, DECEMBER 31st, 1900.

ACCOMPANYING REPORT OF THE SECRETARY.

ASSETS.		
Building and Lot (cost)		$191 730.26
Furniture (cost)		14 554.37
Publications on hand (108 810 copies), inventoried value		13 295.82
Library:		
Cash expended for Books, etc.	$4 926.06	
Estimated Value of Donations	35 073.94	40 000.00
Due from Members	$1 864.10	
" " Non-Members for Publications	133.64	
" for Advertising	1 375.00	3 372.74
Cash		9 929.82
		$272 883.01

LIABILITIES.	
Dues for 1901, paid in advance	$9 528.03
Mortgage Debt	75 000.00
*Funds invested in Society House and Lot, and Library	188 354 98
	$272 883.01

* These funds have been derived from the following sources:

Norman Medal Fund	$1 000.00
Rowland Prize Fund	1 222.50
Collingwood Prize Fund	1 000.00
Donations to Building Funds	45 479.50
Profit on sale of 23d St. House and on Securities	20 319.92
Profit on sale of Historical Sketch	1 488.06
Income Account	62 867.78
McCrea Swift Fund	1 000.00
Fellowship Fund	13 038.28
Compounding Dues Fund	5 865.00
Donations to Library, valued at	35 073.94
	$188 354.98

The Norman Medal, Rowland Prize and Collingwood Prize Funds, no longer exist as such; the obligations under them having been assumed by the Society, with the consent of the donors.

TABLE SHOWING THE COMPENSATION PAID TO PERSONS WHO HAVE BEEN IN THE SERVICE OF THE SOCIETY DURING THE YEAR, AND ITS DISTRIBUTION TO THE SEVERAL ACCOUNTS ACCOMPANYING REPORT OF THE SECRETARY:

NAME.	Publications.	Current Business.	Finance and Accounts.	Library.	Janitor.	Total.
Chas. Warren Hunt, Secretary	$1 475.00	$2 950.00	$675.00	$900.00	.....	$6 000.00
*John Thomson, Treasurer, Jan. 1st to 17th, 1900	.....	.....	4.57	.....	.....	4.57
J. M. Knap, Treasurer, Jan. 17th to Dec. 31st, 1900	.....	.....	95.43	.....	.....	95.43
T. J. McMinn, Asst. Secretary	1 475.50	316.29	.....	295.00	.....	2 086.79
E. H. Frick, Asst. Librarian	144.25	15.00	.....	1 040.75	.....	1 200.00
D. J. Mullen, Stenographer	.....	1 028.37	.....	.....	.....	1 028.37
B. J. Burke, Clerk	.....	1 000.00	.....	.....	.....	1 000.00
M. F. Huckell, Bookkeeper	.....	.....	800.00	.....	.....	800 00
*E. A. Angell, Office Assistant Jan. 1st to April 30th, 1900	107.00	69.75	.....	123.25	.....	300.00
E. R. Roosa, Office Assistant, March 1st to Dec. 31st, 1900	89.66	73.00	.....	232.34	.....	395.00
L. L. Parker, Asst. Librarian	7.50	8.50	.....	530.11	.....	546.11
*W. Waldele, Office Boy, Jan. 1st to Oct. 13th, 1900	.....	207.77	.....	.....	.....	207.77
Louis Gloor, Office Boy	.....	207.16	.....	.....	.....	207.16
H. Stugelemann, Office Boy, Oct. 29th to Dec. 31st, 1900	.....	42.00	.....	.....	.....	42.00
Percy Harrold, Hall Boy	.....	156.00	.....	.....	.....	156.00
Frank E. Harrold, Janitor	.....	.....	.....	.....	$710.00	710.00
*J. Simmons, Cleaner, Jan. 1st to July 31st, 1900	.....	.....	.....	.....	130.50	130.50
*C. Harrold, Cleaner, Aug. 1st to Sept. 9, 1900	.....	.....	.....	.....	31.50	31.50
*B. Wallace, Cleaner, Sept. 29th to Dec. 15th, 1900	.....	.....	.....	.....	104.35	104.35
George Poole, Cleaner, Dec. 15th to Dec. 31st, 1900	.....	.....	.....	.....	19.50	19.50
M. Steinbrenner, Temporary Asst. in Library	11.75	3.75	.....	295.50	.....	311.00
*M. Kingsbury, Temporary Asst. in Library, Jan. 1st to Apr. 21st, 1900	.....	.....	.....	171.00	.....	171.00
*M. Pier, Temporary Asst. in Library, May 8th to July 31st, 1900	.....	.....	.....	138.89	.....	138.89
I. Fredericks, Temporary Typewriter in Library	20 00	3 00	.....	457.00	.....	480.00
*O. Claussner, Temporary Office Asst., Jan. 1st to Feb. 3d, 1900	.....	50.00	.....	.....	.....	50.00
*M. Smallie, Temporary Typewriter, Feb., 2 weeks	.....	18.00	.....	.....	.....	18.00
*J. W. Barney	43.60	.....	.....	.....	.....	43.60
*O. J. Marstrand	5 00	.....	.....	.....	.....	5.00
Totals	$3 379.26	$6 148.59	$1 575.00	$4 183.84	$995.85	$16 282.54

* Not at present in employ of Society.

REPORT OF THE TREASURER.

In compliance with the provision of the Constitution, the Treasurer presents the following report for the year ending December 31st, 1900:

Balance on hand December 31st, 1899			$13 728.36
Receipts from current sources, January 1st to December 31st, 1900			51 495.28
Received from sale of Historical Sketch			45.00
Payment on audited vouchers for current business, January 1st to December 31st, 1900		$45 338.82	
Payment on principal of Bond and Mortgage		10 000.00	
Balance on hand December 31st, 1900:			
In Union Trust Company	$4 597.24		
In Garfield National Bank	4 347.58		
In hands of the Treasurer	985.00	9 929.82	
		$65 268.64	$65 268.64

Respectfully submitted,

J. M. KNAP,

Treasurer, Am. Soc. C. E.

New York, January 8th, 1901.

MONTHLY LIST OF RECENT ENGINEERING ARTICLES OF INTEREST.

(December 13th, 1900, to January 9th, 1901.)

NOTE.—*This list is published for the purpose of placing before the members of the Society the titles of current engineering articles, which can be referred to in any available engineering library, or can be procured by addressing the publication directly, the address and price being given wherever possible.*

LIST OF PUBLICATIONS.

In the subjoined list of articles references are given by the number prefixed to each journal in this list.

(1) *Journal*, Assoc. Eng. Soc., 257 South Fourth St., Philadelphia, Pa., 30c.
(2) *Proceedings*, Eng. Club of Phila., 1122 Girard St., Philadelphia, Pa.
(3) *Journal*, Franklin Inst., Philadelphia, Pa., 50c.
(4) *Journal*, Western Soc. of Eng., Monadnock Block, Chicago, Ill.
(5) *Transactions*, Can. Soc. C. E., Montreal, Que., Can.
(6) *School of Mines Quarterly*, Columbia Univ., New York City, 50c.
(7) *Technology Quarterly*, Mass. Inst. Tech., Boston, Mass., 75c.
(8) *Stevens Institute Indicator*, Stevens Institute, Hoboken, N. J., 50c.
(9) *Engineering Magazine*, New York City, 30c.
(10) *Cassier's Magazine*, New York City, 25c.
(11) *Engineering* (London), W. H. Wiley, New York City, 35c.
(12) *The Engineer* (London), International News Co., New York City, 35c.
(13) *Engineering News*, New York City, 15c
(14) *The Engineering Record*, New York City, 12c.
(15) *Railroad Gazette*, New York City, 10c.
(16) *Engineering and Mining Journal*, New York City, 15c.
(17) *Street Railway Journal*, New York City, 35c.
(18) *Railway and Engineering Review*, Chicago, Ill.
(19) *Scientific American Supplement*, New York City, 10c.
(20) *Iron Age*, New York City, 10c.
(21) *Railway Engineer*, London, England.
(22) *Iron and Coal Trades Review*, London, England.
(23) *Bulletin*, American Iron and Steel Assoc., Philadelphia, Pa.
(24) *American Gaslight Journal*, New York City, 10c.
(25) *American Engineer*, New York City, 20c.
(26) *Electrical Review*, London, England.
(27) *Electrical World and Electrical Engineer*, New York City, 10c.
(28) *Journal*, New England Water-Works Assoc., Boston, 75c.
(29) *Journal*, Society of Arts, London, England.
(30) *Annales des Travaux Publics de Belgique*, Brussels, Belgium.
(31) *Annales de l' Assoc. des Ing. Sortis des Ecôle Spéciales de Gand*, Brusseis, Belgium.
(32) *Memoires et Compte Rendu des Travaux*, Soc. Ing. Civ. de France, Paris, France.
(33) *Le Génie Civil*, Paris, France.
(34) *Portefeuille Economique des Machines*, Paris, France.
(35) *Nouvelles Annales de la Construction*, Paris, France.
(36) *La Revue Technique*, Paris, France.
(37) *Revue de Mecanique*, Paris, France.
(38) *Revue Générale des Chemins de Fer et des Tramways*, Paris, France.
(39) *Railway Master Mechanic*, Chicago, Ill.
(40) *Railway Age*, Chicago, Ill., 10c.
(41) *Modern Machinery*, Chicago, Ill., 10c.
(42) *Transactions*, Am. Inst. Elec. Eng., New York City, 50c.
(43) *Annales des Ponts et Chaussées*, Paris, France.
(44) *Journal*, Military Service Institution, Governor's Island, New York Harbor, 75c.
(45) *Mines and Minerals*, Scranton, Pa., 20c.
(46) *Scientific American*, New York City, 10c.
(47) *Mechanical Engineer*, Manchester, England.
(48) *Zeitschrift des Vereines Deutscher Ingenieure*, Berlin, Germany.
(49) *Zeitschrift für Bauwesen*, Berlin, Germany.
(50) *Stahl und Eisen*, Duesseldorf, Germany.
(51) *Deutsche Bauzeitung*, Berlin, Germany.
(52) *Rigasche Industrie-Zeitung*, Riga, Russia.
(53) *Zeitschrift des oesterreichischen Ingenieur und Architekten Vereines*, Vienna, Austria.
(54) *Den Tekniske Forenings Tidsskrift*, Copenhagen, Denmark.
(55) *Ingeniören*, Copenhagen, Denmark.
(56) *Teknisk Tidskrift*, Stockholm, Sweden.
(57) *Teknisk Ugeblad*, Christiania, Norway.
(58) *Proceedings*, Eng. Soc. W. Pa., 410 Penn Ave., Pittsburg, Pa., 50c.
(59) *Transactions*, Mining Institute of Scotland. London and Newcastle-upon-Tyne.
(61) *Proceedings*, Western Railway Club, 225 Dearborn St., Chicago, Ill., 25c.
(62) *American Manufacturer and Iron World*, 59 Ninth St., Pittsburg, Pa.
(63) *Minutes of Proceedings*, Inst. C. E., London, England.

NOTE.—There are no references made in this month's list to German and Swedish periodicals.

LIST OF ARTICLES.

Bridge.

Economical Steel and Masonry Highway Bridge Work at Rye, N. Y.* (13) Dec. 13.
Swing-Bridges over the Weaver.* (11) Dec. 14.
Raising the Boston Bridge near McKeesport, Pa.* (14) Dec. 15.
Curves of Weight and Specifications for Electric Railway Bridges (13) Dec. 20.
The Widening of London Bridge.* (12) Dec. 21.
An Interlocking Mechanically Operated Draw Bridge Gate.* H. G. Tyrrell. (13) Dec. 27.
Rebuilding of the Kinzua Viaduct.* (18) Dec. 29.
Reinforcing and Rebuilding the Cornwall Bridge Piers.* (14) Dec. 29.
Pont Roulant Électrique de 20 Tonnes de la Maison Ganz et Cie.* (33) Dec. 15.

Electrical.

Electrical Measuring Instruments. J. Franklin Stevens. (24) Serial beginning July 16, ending July 23.
The Operation of a Combined Lighting and Power Plant. J. H. Perkins. (26) Serial beginning Oct. 12, ending Oct. 19.
The Electricity Works of Chèvres (Geneva).* (26) Serial beginning Oct. 12, ending Dec. 7.
Alternating Current Laboratory Experiments and Commercial Tests. Fitzhugh Townsend. (6) Nov.
On the Mechanical Forces in Dynamos Caused by Magnetic Attraction. B. A. Behrend. (42) Nov.
The Plant of the St. Croix Power Co. of Wisconsin.* Henry Floy. (42) Nov.
The Induction Motor. B. A. Behrend. (27) Serial beginning Nov. 3, ending Dec. 29.
Incandescent Lamp Development to the year 1880.* Edwin W. Hammer. (27) Serial beginning Dec. 1, ending Dec. 15.
Swansea Electric Tramways.* (26) Dec. 27.
The Electrical Working of Main Line Railways. Ernest Kilburn Scott. (26) Dec. 7.
The Pollak-Virág Telegraph.* Herr Pinter. (11) Dec. 7.
On the Supersession of the Steam by the Electric Locomotive. W. Langdon. (26) Serial beginning Dec. 7, ending Dec. 14.
Some Notes on the Design of Large Alternators.* A. Heyland. (26) Serial beginning Dec. 7, ending Dec. 21.
Electric Power and Light for the Machine Shop and Foundry. Forrest R. Jones, M. Am. Soc. M. E. (13) Dec. 13.
Leeds Tramway Plant.* (12) Dec. 14.
Some Requisites of Modern Lighting Generator Sets. H. G. Reist. (27) Dec. 15.
The Influences Exerted by Power Factor. F. H. Leonard, Jr. (24) Serial beginning Dec. 17, ending Dec. 24.
Economy of the Application of Electricity in Collieries and Iron and Steel Works.* Ernest D. Phillips. (22) Dec. 21.
Electric Haulage for Collieries.* Ernest Kilburn Scott. (22) Dec. 21.
Electric Power Transmitted 153 Miles. (15) Dec. 21.
Electrical Locomotives and Multiple-Driven Axles. Edward H. Tyler. (11) Dec. 21.
Electrical Locomotives for Mine Haulage.* (22) Dec. 21.
Electricity in Mines and Collieries.* J. E. Hodgkin. (22) Dec. 21.
The Most Recent Progress in the Application of Electricity to Coal Mining Operations.* (22) Dec. 21.
On Rapid Variations in the Current through the Direct-Current Arc.* W. Duddell. (11) Serial beginning Dec. 21, ending Dec. 28.
A Recharging Motor for Electric Vehicles.* (46) Dec. 22.
Direct Connected Railway Generators.* (19) Dec. 22.
Some Electric Furnaces for Laboratory Use.* Charles L. Norton. (27) Dec. 22.
Description of the Works of the Bullock Electric Manufacturing Company, Cincinnati, Ohio.* (62) Dec. 27.
Electric Automobile Trials. (26) Dec. 28.
Some Recent Tests on Electrically-Driven Hoists.* (26) Dec. 28.
The Nernst Lamp.* (26) Dec. 28.
Water Loads for Electricity Works.* W. E. Warrilow. (26) Dec. 28.
Report on Electric Lighting Exhibits at the Paris Exposition. (27) Dec. 29.
The Electric Delivery Equipment of a Large New York Store.* Max Loewenthal. (27) Dec. 29.
Wireless Telegraphy.* (19) Dec. 29.
Electric Fire Risks. Hubert S. Wynkoop. (10) Jan.
Electric Haulage in Belgium on the Charleroi Canal.* Léon Gérard. (10) Jan.
Electrically Operated Machine Tools.* Frank C. Perkins. (41) Jan.
Modern Electric Power Stations; Some Conditions Governing Their Design. Philip Dawson. (10) Jan.
A Court Decision as to Responsibility for Damage by Electrolysis to Gas Mains. (13) Jan. 3.
A *Résumé* of the Electric Street Railway.* O. T. Crosby. (17) Jan. 5.
Electrical Energy Direct from Carbon. (27) Jan. 5.
Electrical Power Transmission. Dr. Louis Bell. (27) Jan. 5.
Electrical Theories. Prof. John Trowbridge. (27) Jan. 5.

---

* Illustrated.

Electrical—(Continued.)

Electricity in the Coming Century. Elihu Thomson. (27) Jan. 5.
Electro-Chemistry. Carl Hering. (27) Jan. 5.
Future Development of Interior Wiring. H. Ward Leonard. (27) Jan. 5.
Light Without Heat. Prof. R. A. Fessenden. (27) Jan. 5.
The Automobile. Harold H. Eames. (27) Jan. 5.
The " C & C Series-Parallel " System of Motor Control.* Geo. Fowler. (27) Jan. 5.
The Capacity and Rating of Railway Motors. Norman Wilson Storer. (17) Jan. 5.
The Electric Power Plant of the Manhattan Railway Company; from the Generators to the Third Rail.* L. B. Stillwell. (17) Jan. 5.
The Storage Battery. Augustus Treadwell, Jr. (27) Jan. 5.
The Telegraph. Patrick B. Delany. (27) Jan. 5.
De la Production et de l'Utilisation de l'Electricité. E. E. Stahl. (36) Serial beginning August 10, ending Oct. 10.
Groupe Electrogène Ringhoffer-Siemens et Halske: Exposition de 1900.* Georges Henry. (33) Dec. 1.
Groupe Electrogène de 1400 Chevaux des Sociétés d'Augsbourg et Nuremberg Réunies de la Société d'Électricité Lahmeyer.* Alfred Boudon. (33) Dec. 8.
Les Génératrices Électriques Lahmeyer à l'Exposition.* G. Leugny. (36) Dec. 10.

Marine.

The Æsthetic Principles of Naval Architecture. (12) Serial beginning Sept. 28, ending Nov. 9.
The Hamburg-American Liner *Deutschland.** (11) Serial beginning Nov. 25, ending Dec. 28.
Laying Out Mine Fields in the Royal Navy.* (26) Dec. 14.
Naval Gun Circuits.* (26) Dec. 21.
The Protected Cruisers of the *St. Louis* Class.* (46) Dec. 22.
Liquid Fuel-Burning Steamer *Bulysses.* (11) Dec. 28.
Modern Ocean Coal Gluttons: The Price of High Ocean Speeds.* George Ethelbert Walsh. (10) Jan.
Steel Ships with Protected Bottoms, Designed for Economical Repairing. Joseph R. Oldham. (10) Jan.

Mechanical.

The Incandescent Gas Mantle and Its Uses. Vivian B. Lewes. (29) Serial beginning Oct. 19, ending Nov. 2.
The Drop Test as a Means of Showing Relative Strength of Draft Gears.* R. P. C. Sanderson. (61) Nov.
A System of Power Transmission by Means of Cams.* (22) Dec. 7.
Cast, Forged and Flanged Work at Paris. (11) Dec. 7.
Evans' Improved Ingot Stripper. (22) Dec. 7.
Machine Tools at the National Show.* (11) Dec. 7.
Road Traction. Professor Hele-Shaw. (29) Dec. 7.
A New Gas Producer.* John A. Purves. (47) Dec. 8.
A New Principle in Gas-Engine Design.* C. E. Sargent, M. Am. Soc. M. E. (13) Dec. 13.
Comparative Value of Different Arrangements of Suction Air Chambers on Pumps.* F. Meriam Wheeler, M. Am. Soc. M. E. (13) Dec. 13.
Ramsay Casting Machine: Latest Type of Pig Iron Conveyor.* (62) Dec. 13.
Boyer Long-Stroke Pneumatic Hammer. (11) Dec. 14.
Feed Water and Boilers. (15) Dec. 14.
New Type of Pumps.* (12) Dec. 14.
Ellis and Eaves' Induced Draught.* (47) Dec. 15.
Apparatus for Dynamically Testing Steam Engine Indicators.* Carleton A. Read. (20) Dec. 20.
The Milwaukee Milling Machines.* (20) Dec. 20.
Engines for the Utilisation of Blast Furnace Gases.* (22) Dec. 21.
Milling Machine Heads at Paris.* (11) Dec. 21.
The Roze Dirigible Airship.* (46) Dec. 22.
Burning Powdered Coal in Stationary Boilers.* (14) Dec. 29.
Economy in the Production and Utilization of Steam. Edward G. Hiller. (47) Dec. 29.
Elevating and Conveying Machinery.* (47) Dec. 29.
Making Chisels and other Tools from Files. Walter J. May. (19) Dec. 29.
Some Automobiles Exhibited at the Paris Exposition.* (46) Dec. 29.
The Westinghouse-Parsons Steam Turbine.* (14) Dec. 29.
Prof. V. B. Lewes and the De Lery Light. Dr. W. H. Birchmore. (24) Dec. 31.
A New Fuel Gas.* (39) Jan.
Coke-Making in the United States. Data from the Famous Connellsville Region.* William Gilbert Irwin. (10) Jan.
Continental Steam Engines as Seen at the Paris Exhibition.* W. D. Wansbrough. (10) Jan.
Tests of the Boiler of the Purdue Locomotive. W. F. M. Goss. (25) Jan.
New Impact Testing Machine and Brick Testing Machine, Purdue University.* William Kendrick Hatt and W. P. Turner. (13) Jan. 3.
The Gas Engine at the Beginning of the Twentieth Century. J. D. Lyon. (62) Jan. 3.

* Illustrated.

Mechanical—(Continued).

The Steam Engine of To-Day in the Field of Electrical Engineering Practice. Dr. R. H. Thurston. (27) Jan. 5.
The Steam Plant and Third-Rail Equipment of the Manhattan Railway.* W. E. Baker. (17) Jan. 5.
Essais d'une Turbine à Vapeur Parsons avec un Alternateur de 1 000 Kilowatts. W. H. Lindley, Prof. M. Schröter et Dr. H. F. Weber. (37) Nov.
Note sur la Traction Mécanique des Chariots à Bagages.* M. Sabouret. (38) Nov.
Résultats les Plus Marquants de l'Étude Théorique et Expérimentale sur le Frottement Médiat. N. Pétroff. (37) Nov.
L'Éclairage à l'Exposition de 1900.* H. Guérin (33) Serial beginning Dec. 1, ending Dec. 15.

Metallurgical.

The Analysis of Slags and Cinders. C. H. Joüet. (6) Nov.
On the Magnetic Separation of Iron Ores. Dr. Hermann Wedding. (22) Dec. 7.
Shot Iron: How to Recover It and How to Use It. C. H. Putnam. (11) Dec. 14.
On the Tempering of Iron Hardened by Overstrain. (47) Dec. 15.
The Tropenas Steel Castings Process.* (18) Dec. 15.
Pyritic Smelting and Hot Blast. S. E. Bretherton. (16) Dec. 29.
A Century of Blast Furnace Practice.* Walter Kennedy. (62) Jan. 3.
The Metallurgic Uses of Aluminium.* (19) Jan. 5.

Military.

United States Naval Proving Ground, Indian Head.* Lieut. Jos. Strauss. (46) Dec. 29.

Mining.

Electricity in Mining: Principles Governing the Calculation, Construction and Operation of Electrical Installations.* R. B. Williamson. (45) Serial beginning May, ending August.
The Cripple Creek Mining District, Colorado.* Dr. S. F. Hazlehurst. (16) Serial beginning Oct. 20, ending Dec. 8.
The Biwabik Ore Mine.* (20) Dec. 13.
The Pittsburg and Buffalo Coal Company's Mines.* (16) Dec. 22.
Notes on the Fossil Iron Ores of Georgia.* S. W. McCallie. (16) Dec. 29.
Pumps for Mine Service.* (45) Jan.
The American Nettie: A Mine Furnishing an Illustration of the Peculiar Cave Deposits and the Method of Mining Them near Ouray, Colorado.* Prof. Arthur Lakes. (45) Jan.
Use of Concrete in Mining. Its Adaptability for Lining Shafts and Drifts, and for Making Stoppings. M. Marcel Habets. (45) Jan.
Prestongrange Colliery. (59) vol. 22, Pt. I.
Weight of Winding-Drums for Deep Shafts. Daniel Burns. (59) Vol. 22, Pt. I.
L'Abatage Mécanique du Charbon.* Félix Colomer. (36) Dec. 10.

Municipal.

Uniformity in Municipal Reports. M. N. Baker. (28) Dec.
Landscape in Connection with Public Buildings in Washington. Frederick Law Olmsted, Jr. (14) Dec. 29.
Repairs to Asphalt Pavements in Buffalo. (14) Jan. 5.

Railroad.

Street Car Building. Charles Henry Davis. (17) Serial beginning Feb. 3, 1900, ending Jan. 5, 1901.
Experience with Electric Traction on Trunk Railways. N. H. Heft. (17) Serial beginning August 25, ending Sept. 8.
Locomotives at the Paris Exhibition: Express Compound Locomotive, Southern Railway of Italy.* (12) Serial beginning Oct. 5, ending Nov. 2.
Transportation Exhibit of the United States at the Paris Exposition of 1900.* (18) Serial beginning Oct. 6, ending Nov. 3.
Railway Yards and Terminals.* E. E. Russell Tratman. (61) Nov.
Hot Boxes—Their Causes and Preventatives. L. C. Bundy. (39) Dec.
Train Delays. (39) Dec.
Derailments. J. H. Wallace. (47) Dec. 8.
Rapid Earthwork Calculation. H. P. Gillette. (13) Dec. 13.
The Railway Tax System of Michigan. (40) Dec. 14.
New Denver Shops of the Colorado Southern Ry.* Richard English. (18) Dec. 15.
Train Lighting. (18) Dec. 15.
Expert Valuation of Railway and other Corporate Property in Michigan. (13) Dec. 20.
The Kennedy-Morrison Rail Finishing Process.* (20) Dec. 20.
Either-Side Brake.* (12) Dec. 21.
Locomotive Design. (15) Dec. 21.
The Bessemer Heavy Traffic Freight Route. (15) Dec. 21.
The Erie's Six-Wheel Switching Locomotives—Wide Fire-Box.* (15) Dec. 21.
The Santa Fé Roadbed Leveler.* (40) Dec. 21.
The Nashville Union Station.* (18) Dec. 22.

---

* Illustrated.

Railroad—(Continued).

The Price Patent Momentum Friction Brake.* (47) Dec. 22.
Modern Locomotive Design. Waldo H. Marshall, M. Am. Soc. M. E. (13) Dec. 27.
Heating System of the Clinton Roundhouse.* (15) Dec. 28.
Heavy Ten-Wheel Compound Passenger Locomotives with Wide Fire-Box—Lehigh Valley Railroad.* (15) Dec. 28.
Oil as Locomotive Fuel in California.* (40) Dec. 28.
Landscape Gardening in Maintenance of Way Work. Louville Curtis. (19) Dec. 29.
The Halford Gradient Railway.* (46) Dec. 29.
A Modern Roundhouse, Chicago & Northwestern Railway, at Clinton, Ia.* (25) Jan.
Center Plates.* Edward Grafstrom. (25) Jan.
Effective Lubrication of Driving Boxes.* (25) Jan.
Four-wheel Steel Frame Truck and Steel Frame Draft Gear for Passenger Equipment, Lake Shore & Michigan Southern Railway.* (25) Jan.
Gravity Planes—Number of Cars Required. (45) Jan.
Low Drop-bottom Gondola Car, 80 000 lbs. capacity: Chicago & Northwestern Railway.* (25) Jan.
The Large Steel Car. Its Development and Position in the Business of Railroads. W. S. Morris. (25) Jan.
Method of Procedure in Remodeling Freight Yards. W. C. Cushing. (15) Jan. 4.
Telephone Train Despatching. G. F. J. (15) Jan. 4.
The Design of Structural Steel Cars.* George I. King. (15) Jan. 4.
The Storage Air Brake System.* (17) Jan. 5.
Nouveau Systèmes de Distribution pour Locomotives.* Pierre Guédon. (34) Serial beginning Sept., ending Nov.
Les Appareils de Sécurité des Chemins de Fer à l'Exposition de 1900. (36) Serial beginning Sept., 25, ending Oct. 10.
Chemin de Fer Transsibérien Traversée du Lac Baikal.* Platon Yankowsky. (32) Nov.
Les Chemins de Fer de Siberie. M. A. Jacqmin. (32) Nov.
Les Chemins de Fer et les Tramways à l'Exposition Universelle de 1900: Matériel et Objets Exposés par la Compagnie d'Orléans.* (38) Nov.
Locomotive Mixte Compound à Trois Cylindres des Chemins de Fer du Jura-Simplon.* F. Barbier. (33) Dec. 1.
Locomotive à Grande Vitesse "Compound-Tandem" Construite par l'Usine Poutiloff, à Saint-Pétersbourg.* F. Barbier. (33) Dec. 8.
Les Wagons en Acier Moulé sous Pression.* (36) Dec. 10.
Quelques Observations Relatives aux Locomotives à l'Exposition de 1900. (36) Dec. 10.
Le Chemin de Fer Transsibérien. Son Influence Économique sur l'Industrie Minière en Sibérie et sur le Commerce International.* G. de Krivochapkine. (33) Serial beginning Dec. 15, ending Dec. 22.

Sanitary.

The Economical Disposal of Town Refuse. Brierley Denham Healey. (47) Serial beginning July 14, ending July 28.
Purification of Sewage by Bacterial Methods.* Leonard P. Kinnicutt. (28) Dec.
Paris Drainage and Water Supply. (12) Dec. 14.
The Treatment of London Sewage. Prof. Frank Clowes. (29) Dec. 14.
Results Obtained with Large Experimental Septic Sewage Tanks and Rapid Filtration at Woonsocket, R. I. Geo. A. Carpenter. (13) Dec. 20.
Plumbing Details in the Residence of Dr. E. H. Dunham.* (14) Dec. 22.
The Brookfield, Mo., Sewerage System. R. P. Garrett. (14) Dec. 22.
The Septic Tank Experiments of the Massachusetts State Board of Health. (14) Dec. 22.
Inspecting and Cleaning an Intercepting Sewer at Columbus, O. (13) Dec. 27.
Heating of the Westminster Chambers, Boston.* (14) Jan. 5.
Les Appareils de Chauffage à l'Exposition de 1900.* (33) Dec. 15.

Structural.

Steel: Its Properties and Tests. (26) Serial beginning Sept. 7, ending Oct. 19.
Iron and Steel at the Paris Exhibition.* Prof. H. Bauerman. (47) Serial beginning Sept. 22, ending Oct. 20.
Eliminating the Conflagration Hazard. Everett U. Crosby. (28) Dec.
The Great Northern Paper Company's New Mills.* (14) Dec. 15.
A Steel-Concrete Stable Roof.* (14) Dec. 22.
Some Recent Tests of American Iron and Steel. J. Walter Esterline and Robert B. Treat. (27) Dec. 22.
The Highest Chimney in the World. (24) Dec. 24.
Foundations on a Waterlogged Subsoil.* C. S. Vesey Brown, Assoc. M. Inst. C. E. (10) Jan.
Tension Impact Tests of Rolled Steel.* S. Bent Russell, M. Am. Soc. C. E. (13) Jan. 3.
Construction and Equipment of a Bridge Shop Plant.* (14) Jan. 5.
The Power House and Sub-Station Buildings of the Manhattan Railway Company.* George H. Pegram. (17) Jan. 5.
Fabrication des Agglomérés Silico-Calcaires: Procédé Schwarz*. H. Cuénod. (33) Dec. 1.

---

* Illustrated.

Topographical.

The Transcontinental Triangulation and the American Arc of the Parallel. John E. McGrath. (13) Jan. 3.

Water Supply.

A Successful Siphon.* Robert S. Hale. (1) Nov.
The Experimental Filter Plant at Pittsburgh.* Morris Knowles. (1) Nov.
Description of Experimental Filter Plant at Pittsburgh and Results of Experiments.* Morris Knowles. (28) Dec.
The Snoqualmie Falls Water-Power Plant and Transmission System.* (13) Dec. 13.
A Continuous Automatic Water Purifier.* (15) Dec. 14.
Iron Removal from the Preuzlau Water Supply.* (14) Dec. 15.
Testing the Capacity of Turbines. Edward P. Burch. (27) Dec. 29.
A Self-Governing Impulse Water-Wheel.* (13) Dec. 27.
Removal of Iron from Water. (14) Dec. 29.
Water Softening Plant of the Cincinnati, Hamilton and Dayton Railway.* (15) Jan. 4.
A Combination Hydraulic and Steam Power Plant, Stuyvesant Falls, N. Y.* (14) Jan. 5.

Waterways.

The Isthmian Canal Commission's Report. (14) Serial beginning Dec. 8, ending Dec. 15.
The Preliminary Report of the Isthmian Canal Commission. (13) Serial beginning Dec. 20, ending Dec. 27.
The Concrete Lock near St. Paul. (14) Dec. 22.
The New Hoboken Terminal of the North German Lloyd Line.* (14) Dec. 22.
Design for Controlling Works at the Head of the Chicago Drainage Canal.* (13) Jan. 3.
The New Fireproof Piers of the North German Lloyd Steamship Co., at Hoboken, N. J.* (13) Jan. 3.
The Engineering Works of the Suez Canal. (14) Jan. 5.

---

* Illustrated.

NEW BOOKS OF THE MONTH.

Unless otherwise specified, books in this list have been donated to the Library by the Publisher.

SPECIFICATIONS FOR STEEL BRIDGES.

(Taken from "De Pontibus.") By J. A. L. Waddell. Cloth, 7 x 4½ ins., 178 pp. New York, John Wiley & Sons, 1900. $1.00.

There being a considerable demand for the specifications of "De Pontibus," the author and publishers of that work have printed the specifications, together with the tables and diagrams, separately from the other chapters. This was done that the specifications might be obtained at much less than the cost of the original treatise.

A few changes have been made in order to bring the specifications up to date. There is an index of twenty-two pages.

NOTES ON SOME EUROPEAN IRON-MAKING DISTRICTS.

A Collection of Letters to *The Iron Age*. By C. Kirchhoff. Boards, 9 x 6 ins., 113 pp., illus. (Donated by the Author.)

This is a series of letters embodying the results of observations made on visits to iron and steel plants in Germany, the Minette District of Lorraine, and England. It includes descriptions of the coal and iron supplies of those districts.

GEMEINFASSLICHE DARSTELLUNG DES EISENHÜTTENWESENS.

Herausgegeben vom Verein Deutscher Eisenhüttenleute in Düsseldorf. Cloth, 9 x 6 ins., 144 pp., illus. Düsseldorf, A. Bagel, 1901.

The Contents are: Part 1, Die Darstellung des Roheisens; Die Darstellung des schmiedbaren Eisens; Die Formgebungsarbeiten. Part 2, Das Eisengewerbe in den einzelnen Hauptländern.

FIELD MANUAL FOR ENGINEERS.

By Philetus H. Philbrick. Leather, 7 x 4 ins., 388 pp. New York, John Wiley & Sons, 1901. $3.00. (Donated by the Author.)

The preface states that the aim in this work has been: First, To present the subjects of the text in a mathematical and logical order. Second, To classify all problems presented so as to be easily referred to. Third, Especial care has been taken to express the resulting formula of every problem in the form requiring the least numerical computation. Fourth, To furnish a large number of useful tables, more complete, more extended, and, where possible, with more elementary and appropriate arguments than other similar tables possess. Fifth, To treat the general problems of Railway Engineering more extensively than other similar works have done.

The headings of chapters are: Preliminary Operations; Adjustments, Use, and Care of Instruments; Plane Trigonometry; Simple Curves Connecting Right Lines; Leveling, Stadia Measurements, etc.; Compound Curves; Reversed Curves; Turnouts; The True Transition Curve; Calculation of Earthwork; Approximate and Abridged Computations; Construction; Explanation of Tables and Miscellaneous Topics; Tables. There is an index of three pages.

STREET RAILWAY ROADBED.

By Mason D. Pratt, Assoc. M. Am. Soc. C. E., and C. A. Alden, Assoc. M. Am. Soc. C. E. Cloth, 9 x 6 ins., 135 pp., illus. New York, Street Railway Publishing Company, 1898. $2.00. (Donated by the Authors.)

The authors state that the subject-matter of this book is mostly made up from contributions to the *Street Railway Journal*, *Engineering News* and *Proceedings*, Am. Soc. C. E. It is not supposed to cover the entire field of street railway track construction, but to present in compact form the main points of the best practice of to-day. The headings of chapters are: Early Types of Rails; The Development of the Girder Rail; What Governs the Shape of Rails; The T-Rail Adapted to Street Railways; Track Fastenings and Joints; Special Work; Guard-Rails; Advantages of Spiral Curves and Tables for Same; Design of Special Work; Surveys and Laying Out Work; Specifications; Index.

WATER POWER;

An Outline of the Development and Application of the Energy of Flowing Water. By Joseph P. Frizell, M. Am. Soc. C. E. Cloth, 9 x 6 ins., 563 pp., illus. New York, John Wiley & Sons, 1901. $5.00. (Donated by the Author.)

The author states that this is in no sense an elementary work. It assumes the reader to be possessed of elementary notions of mechanics and mathematics. The work does not attempt to go much into constructive details. It directs the reader's attention to the principles involved in the design, and the results to be aimed at. The contents are: Natural Watercourses; Dams for Water-Power; Construction of Dams; Dams of Masonry; Appendages of Dams; Movable Dams; Storage Reservoirs and Reservoir-Dams; Rock-Fill Dams; Reservoir-Dams of Masonry; Examples of High Dams; Failures of High Dams; Canals, Gates, etc.; Hydraulic Motors; Water-Wheels; Turbines; Appendages and Attachments of Turbines; Canals; Development of Natural Water-Powers; Transmission of Power; Shafting and Wire Rope; Hydraulic Transmission; Transmission by Compressed Air; Transmission by Electric Current; The Power-House; Measurement of Water; Storage and Pondage of Water; Damages to Mill-Owners Resulting from the Diversion of Water.

MEMEL-, PREGEL- UND WEICHSELSTROM, IHRE STROMGEBIETE UND IHRE WICHTIGSTEN NEBENFLÜSSE.

Eine hydrographische, wasserwirthschaftliche und wasserrechtliche Darstellung. Auf Grund des Allerhöchsten Erlasses vom 28. Februar, 1892, im Auftrage des preussischen Wasser-Ausschusses herausgegeben von H. Keller, Geheimer Baurath, Vorsteher des Bureaus des Ausschusses. Cloth, 6 vols., 11 x 7 ins. (atlas, 21 x 18). Berlin, Dietrich Reimer, 1899. (Donated by P. Glasenapp.)

The Contents are: Vol. 1, Stromgebiete und Gewässer; Vol. 2, Memel und Pregelstrom; Vol. 3, Weichselstrom in Schlesien und Polen; Vol. 4, Weichselstrom in Preussen; Vol. 5, Tabellen; Vol. 6, Kartenbeilagen.

INDEX TO ENGINEERING NEWS

For the years 1890 to 1899, inclusive. Compiled by Mary E. Miller. Cloth, 324 pp., 9 x 6 ins. New York, The Engineering News Publishing Co., 1900. $2.50.

DONATIONS TO THE LIBRARY.

From Dec. 13th, 1900, to Jan. 9th, 1901.

Alden, C. A., and M. D. Pratt. 1 bound vol.
Am. Inst. of Min. Engrs. 12 pam.
Australasian Inst. of Min. Engrs. 1 pam.
Baker, I. O. 3 vol.
Belzner, T. 3 pam.
Berg, Walter G. 1 pam.
Boston Pub. Lib. 1 vol.
Cal. Acad. of Sci. 1 pam.
Conn. R. R. Commrs. 1 bound vol.
Cornell Univ. 1 vol.
Eiffel, G. 1 vol., 1 pam.
Endicott, Mordecai T. 1 pam.
Eng. News Pub. Co. 1 bound vol.
France—Ministère des Travaux Publics. 1 vol.
Frizell, J. P. 1 bound vol.
Glasenapp, P. 6 bound vol.
Grimm, C. R. 14 phot.
Hermann, E. A. 1 bound vol.
Industrial Water Co. 2 pam.
Inst. of Engrs. and Shipbuilders in Scotland. 1 bound vol.
Ironmonger, The. 1 bound vol.
Kingman, Lewis. 1 bound vol.
Kirchoff, C. 1 bound vol.
Lewis, James F. 1 pam.
Merchants' Assoc. of N. Y. 1 pam.
Nelles, George T. 2 pam.
N. Y. State Board of Health. 4 bound vol.
North, Edward P. 1 bound vol.
Osgood, Joseph O. 1 bound vol., 11 vol.
Ottawa Literary Sci. Soc. 1 vol.
Philbrick, Philetus H. 1 bound vol.
Schneider, C. C. 1 pam.
Seward, George F. 1 pam.
Smithsonian Inst. 1 bound vol.
Sturtevant, B. F., Co. 1 pam.
Thompson, Robert A. 2 vol.
Thomson, John. 1 bound vol., 7 pam.
U. S. Bureau of Foreign Commerce. 7 vol.
U. S. Commr. of Navigation. 1 bound vol.
U. S. Corps of Engrs. 50 pam., 15 specif.
U. S. Geological Surv. 6 bound vol., 2 pam.
U. S. Naval Observatory. 1 pam.
Verein Deutscher Eisenhüttenleute. 1 bound vol.
Villalon, José R. 1 pam.
Wiley, John & Sons. 1 bound vol.

MEMBERSHIP.

ADDITIONS.

MEMBERS.

	Date of Membership.
SARLE, OLIVER PERRY, Jr.,	
Shedd and Sarle, 146 Westminster St., Providence, R. I.	Jan. 2, 1901
SPOONER, ALLEN NEWHALL,	
Asst. Eng., Dept. Docks and Ferries, Foot of 24th St., East River, New York City	Dec. 5, 1900
VALUE, BEVERLY REID,	
Div. Eng., Rapid Transit R. R. Commission, 231 West 125th St., New York City	Jan. 2, 1901

ASSOCIATE MEMBERS.

BLODGETT, JOHN,	Jun.	Dec. 4, 1889
Care of Keystone Bridge Works, Pittsburg, Pa.	Assoc. M.	Jan. 2, 1901
BRACE, JAMES HENRY,		
De Graaf Bldg., Albany, N. Y.		Jan. 2, 1901
BURDEN, MORTON,	Jun.	Feb. 4, 1896
276 Arlington St., Youngstown, Ohio	Assoc. M.	Jan. 2, 1901
HELM, EDWIN GUY,		
134 Collinsville Ave., East St. Louis, Ill.		Dec. 5, 1900
JACKSON, JAMES MADISON,		
City Engineer, Parkersburg, W. Va.		Jan. 2, 1901
LEPPER, FRED WILLIAM,		
New Federal Bldg., Chicago, Ill.		Jan. 2, 1901
MCREYNOLDS, ORVAL OMAR,		
Chf. Eng., The Twin Lakes Reservoir Co., and The Twin Lakes Land & Water Co., 227 Central, Block, Pueblo, Colo.		Dec. 5, 1900
MALUKOFF, ALEXIS JOSEPH,		
72 West 131st St., New York City		Jan. 2, 1901
MOREY, RICHARD,		
Eng. and Man., Gilsonite Roofing and Paving Co., 716 New York Life Bldg., Kansas City, Mo.		Jan. 2, 1901
ROWELL, GEORGE FREEMAN,		
Asst. Eng., Pennsylvania Water Co., 701 Wood St., Station D, Pittsburg, Pa.	Jun.	May 4, 1897
	Assoc. M.	Jan. 2, 1901
THORNLEY, JULIAN,		
Asst. Eng., Rapid Transit R. R. Commission, 231 West 125th St., New York City.		Jan. 2, 1901
WATSON, WILBUR JAY,	Jun.	Oct. 4, 1898
504 Osborn Bldg., Cleveland, Ohio.	Assoc. M.	Jan. 2, 1901

	Date of Membership.
WHISTLER, JOHN T	
Isthmian Canal Commission, Washington, D. C.	Jan. 2, 1901
WHITE, WILLIAM MACINTIRE,	
Pencoyd Iron Works, Pencoyd, Pa.	Jan. 2, 1901
WOODARD, SILAS,	
Asst. Eng., Isthmian Canal Commission, 73 Corcoran Bldg., Washington, D. C.	Jan. 2, 1901

JUNIORS.

HAMILL, ALEXANDER, Jr.,	
Jersey City, N. J.	Dec. 28, 1900
PRUETT, WILLIAM ELISHA,	
Asst. Eng., Waddell & Hedrick, 664 Gibraltar Bldg., Kansas City, Mo.	Dec. 4, 1900
THOMSON, ALEXANDER, Jr.,	
517 Lexington Ave., Brooklyn, N. Y.	Dec. 4, 1900
VAN LOAN, SETH MORTON,	
Catskill, N. Y.	Dec. 28, 1900

RESIGNATIONS.

ASSOCIATE MEMBER.	Date of Resignation.
MITCHELL, EDWIN	Dec. 28, 1900

JUNIOR.

FOUQUET, LOUIS DOUGLAS	Dec. 28, 1900

DEATHS.

DORSEY, EDWARD BATES.....Elected Member, June 4, 1879; date of death unknown.

MERIWETHER, NILES.....Elected Member Nov. 1, 1871; died Dec. 28, 1900.

STARLING, WILLIAM.....Elected Member Sept. 7, 1887; died Dec. 11, 1900.

Vol. XXVII. JANUARY, 1901. No. 1.

AMERICAN SOCIETY OF CIVIL ENGINEERS.

INSTITUTED 1852.

PAPERS AND DISCUSSIONS.

NOTE.—This Society is not responsible, as a body, for the facts and opinions advanced in any of its publications.

CONTENTS.

Paper to be presented: PAGE.

Flow in the Sewers of the North Metropolitan Sewerage System of Massachusetts.
By THEODORE HORTON, Assoc. M. Am. Soc. C. E..... 2

Discussions on Papers which have been presented:

The Preservation of Railway Ties in Europe.
By Messrs. WARD BALDWIN and H. J. HOWE..... 11

The Theory and Practice of Precise Leveling.
By Messrs. W. S. WILLIAMS, J. A. OCKERSON and C. L. CRANDALL..... 13

Some Peculiar Railroad Bridge Accidents.
By JOSEPH MAYER, M. Am. Soc. C. E..... 22

The Practical Column under Central or Eccentric Loads.
By ALBERT I. FRYE, M. Am. Soc. C. E..... 23

The Kinzua Viaduct of the Erie Railroad Company.
By Messrs. GEORGE S. MORISON, R. S. BUCK and L. S. MOISSEIFF..... 27

A Direct Method of Spacing Rivets and Finding the Position, Etc., of Stiffeners in Plate Girders.
By Messrs. BERNT BERGER and F. W. SKINNER..... 39

Vol. XXVII. JANUARY, 1901. No. 1.

AMERICAN SOCIETY OF CIVIL ENGINEERS.

INSTITUTED 1852.

PAPERS AND DISCUSSIONS.

NOTE.—This Society is not responsible, as a body, for the facts and opinions advanced in any of its publications.

FLOW IN THE SEWERS OF THE NORTH METROPOLITAN SEWERAGE SYSTEM OF MASSACHUSETTS.

By THEODORE HORTON, Assoc. M. Am. Soc. C. E.

TO BE PRESENTED MARCH 6TH, 1901.

During the past few years several series of current meter observations have been carried on at intervals in the Metropolitan Sewers in the vicinity of Boston, Mass., for the purpose, first, of obtaining a suitable means for recording the daily flow of sewage pumped at the various pumping stations, and, secondly, of studying the changes in the carrying capacities of the sewers, due to the deterioration of the internal surfaces. Data for the flow of sewage in channels of large size are somewhat scarce, and, therefore, the writer feels justified in presenting a short description of a portion of the work which he thinks may be of interest, and perhaps of service, to many.

The work was done under the direction of William M. Brown, Jr., M. Am. Soc. C. E., Chief Engineer of the Metropolitan Sewerage Commission, and was carried out under the immediate charge of the writer.

NOTE.—These papers are issued before the date set for presentation and discussion. Correspondence is invited from those who cannot be present at the meeting, and may be sent by mail to the Secretary. Discussion, either oral or written, will be published in a subsequent number of *Proceedings*, and, when finally closed, the papers with discussion in full will be published in *Transactions*.

The portion of the work herein described consisted of three series of observations made in the channels of the North Metropolitan system, below the Charlestown and the East Boston pumping stations. The first series was made in 1896, soon after the pumping stations and systems at these points had been put in operation. The next series was made in 1897, after these channels had been in operation about two years, during which time ample opportunities for changes in the carrying capacities had taken place. The third or last series took place in 1900, and was made just previous to the tests of the additional pumping plants recently installed at these stations, in order that a suitable rating of the channels could be made for obtaining the quantity of sewage discharged by the pumps during these tests.

The methods used in carrying out these sets of experiments were, with slight modifications, the same in all cases. An Ellis current meter, with four vanes, and provided with an electrical recording instrument, was used. Previous to each series of observations, it was carefully rated over a course varying in length from 500 to 1 000 ft., and for varying speeds. From these tests a rating chart was constructed for use in the calculations.

The points selected for carrying out these observations were at manholes located some distance below the pumping stations, where the flow was free from any disturbing influence of the pumps. The points were about 800 ft. below the stations, in each case, and were far removed from any changes in alignment, cross-section or grade of the sewer. Below the East Boston pumping station the cross-section of the sewer is a 9-ft. circle of 12-in. brick work, cement-washed, with a hydraulic gradient of 1: 3 000. Only one small local connection enters this stretch of sewer. No changes in grade occur within a distance of 7 000 ft. below the pumping station. At a point 2 000 ft. below the pumping station, there is a change from a circular section to a horse-shoe section of the same equivalent area. This section continues for a distance of 2 000 ft. and then returns to a circular section. Below the Charlestown pumping station, the cross-section of the sewer is 6 ft. x 6 ft. 8 ins., basket-handle, of 8-in. brickwork, cement-washed, with a hydraulic gradient of 1: 2 000. The cross-section and grade are uniform for a distance of about 5 000 ft. below the pumping station, and no local connections enter the sewer within this distance.

In order to determine whether the change of section in the East

Boston channel would have any appreciable effect on the flow in the circular section above it, simultaneous observations of depth were made along this channel for various rates of pumping. These measurements showed that no sensible variation of depth of flow occurred, except near the point where the cross-section changes; and that, for the stretch of channel where the observations were carried on, the flow line and invert were sensibly parallel. Such a study, below the Charlestown pumping station, was not deemed necessary, owing to the greater length of uniform section and grade.

Before operations in the channel were commenced, careful gaugings of the cross-sections were made; graduated straight-edges, provided with plumb-bobs, were inserted; suitable gauges erected for observing the depth of flow in the channel; and a platform hung in convenient position from which to operate the meter.

For the purpose of determining more exactly the position of the current meter while taking observations, a modification of the usual method of using this form of Ellis meter was adopted. The meter was run upon a $\frac{3}{4}$-in. graduated steel rod, in such a manner that it could be clamped at any desired position along the rod. In taking a reading the meter was immersed, one end of the rod was placed in the current, firmly against the side of the channel, and the other end held firmly in the hand and centered at a definite point on the straight-edge—the straight-edge being secured in a horizontal position across the channel and slightly above its center. In this position the meter rotated freely upon the rod, which in turn could be held in any direction in a plane at right angles to the axis of the channel. The position of the meter could thus be located in the following manner: by a distance along the steel rod from the wetted perimeter in a radial line from the central point on the straight-edge; a vertical position in reference to the horizontal straight-edge, measured vertically by a graduated wire attached to the central axis of the meter; a horizontal distance measured along the graduated straight-edge in reference to the vertical diameter of the channel. It is thus seen that the position of the meter was fixed by three measurements, of which only two were necessary, the third one affording a check. In fact, too much attention cannot be given to this point, especially with channels of moderate size, and in which the variations of the velocity in the cross-sections may be great.

In taking the observations, two men were stationed on the platform, one to hold the meter and rod in the desired position, the other to observe the vertical and horizontal position with reference to the straight-edge. The positions of the meter were usually selected in advance. Beginning with the meter at a distance of 0.25 ft. from the wetted perimeter, individual velocity readings were taken successively at each foot and half-foot to the right and left of the vertical diameter of the channel. The meter was then run up the rod to a distance of 0.5 ft. from the wetted perimeter, and a second set of readings taken to the right and left of the vertical diameter, and so on.

On the surface of the ground a third man recorded the revolutions of the meter by means of a stop-watch and electrical clock register. As an Ellis meter of this type registers only half revolutions, and as the intervals for single readings were sometimes necessarily short, dial readings of the electrical instrument were not used, but, instead, the revolutions were counted directly by means of the stop-watch and by listening to the click of the electrical register. A fraction of a revolution could thus be easily estimated. The interval for each single observation was usually 1 minute, but ranged from 30 seconds to 2 minutes, according to the time available for a complete cross-sectional measurement. If run for a longer interval than 2 minutes, it was found that the interferences from clogging and the interruptions of the electrical recording apparatus became so numerous as to interfere seriously with the measurements.

Between each of the individual readings the meter was taken out and carefully inspected to determine whether any foreign matter had lodged upon it in such a way as to affect its correct registration. The frequency with which such small interferences occurred seemed a serious draw-back at first, but by selecting a suitable time interval, by careful inspection of the meter, by noting carefully any deviation in the initial rate at which the meter registered when first immersed, and by comparing the consistency in the final results, errors from such sources were easily determined. All suspicious readings were, of course, repeated, and frequent check readings were made during a cross-sectional measurement.

Before starting a cross-sectional determination for any given depth, the pumping at the station was maintained at a uniform rate until the flow had become constant and free from any possibility of accelera-

tion or back-water. This was easily determined by frequent gauge readings at the observation manhole, and when uniform flow was once established it was maintained, within close limits, until the desired number of meter readings had been taken. These conditions were easily maintained, except when the pumping was at a rate different from the normal rate of flow in the sewer, in which case the pumps were working against a variable lift and required constant changes in the speed in order to maintain a constant discharge. During observations with low flows, the sewage stored up in the suction sewer was utilized in furnishing an increased discharge for high rates of flow.

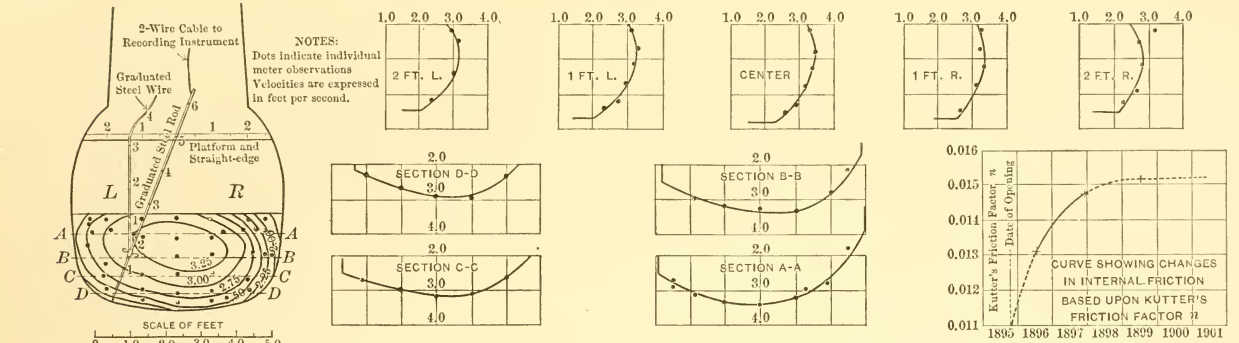
In working up the results of these measurements, graphical methods were used entirely. Cross-sections of each channel, to suitable scale, were plotted from the actual gaugings taken in the sewer at the observation manhole.

A separate sheet of cross-section paper was devoted to each sectional measurement, and upon it were plotted the sewer section, the straight-edge, the average water line, and the various positions of the current meter during the sectional measurement, with the corresponding velocities computed from the field notes and rating chart. Vertical and horizontal lines were then drawn so as to include as many positions of the meter as possible, and, by means of these, suitable horizontal and vertical velocity curves were constructed. The method previously described for placing the meter in position, during the observations, brought most of the positions of the meter on vertical lines at even distances on each side of the vertical diameter. This was not the case with the horizontal lines, although the points lie sufficiently close to the selected horizontal lines to approximate closely the desired purpose. From these horizontal and vertical velocity curves, points on the cross-section were obtained, through which iso-velocity curves could be drawn and the fluid prism calculated. It will be seen that such a set of auxiliary horizontal and vertical curves gives independent locations of points for the iso-velocity curves, and, when there was any apparent disagreement, the mean location of the point was adopted.

This method of developing a sectional measurement is shown in detail in Fig. 1, the upper set of diagrams corresponding to No. I of the Charlestown series of 1900, and the lower set to No. IV of the East Boston series of 1900.

METROPOLITAN SEWERAGE, SHOWING VERTICAL AND HORIZONTAL VELOCITY CURVES, ISO-VELOCITY CURVES AND CURVE OF INTERNAL FRICTION.

CHARLESTOWN CHANNEL; 6′0″ x 6′8″, BASKET-HANDLE SECTION; GRADE 1:2000.



EAST BOSTON CHANNEL; 9′0″ CIRCULAR SECTION; GRADE 1:3000.

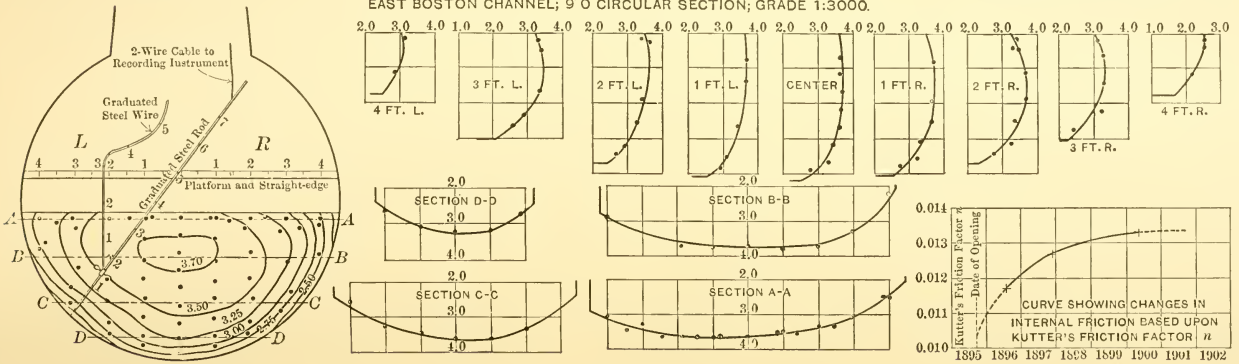


FIG. 1.

The volumes of the fluid prisms were computed according to the prismoidal formula, and the results were tabulated and compared with the Kutter formula according to values of n. From a comparison of these values, a suitable value of n was then selected, from which, with the geometrical elements of the cross-section, a discharge table could be constructed for use at each pumping station.

The results of these observations, arranged in series according to the periods at which the observations were made, are shown in Table No. 1.

TABLE No. 1.

No.	Depth.	Q, in cubic feet per second.	Mean velocity.	Hydraulic radius.	C.	n.
Series of July, 1896. Charlestown Pumping Station.						
I.	1.02	8.60	1.99	0.688	107	0.0129
II.	1.44	16.59	2.46	0.958	112	0.0131
III.	1.91	26.81	2.82	1.187	115	0.0132
IV.	2.40	38.82	3.13	1.387	118	0.0133
V.	2.89	52.90	3.44	1.539	124	0.0130
Series of July, 1896. East Boston Pumping Station.						
I.	1.02	6.10	1.58	0.619	110	0.0122
II.	1.52	15.67	2.21	0.928	126	0.0117
III.	2.04	29.40	2.70	1.208	134	0.0116
IV.	2.45	42.18	3.03	1.408	139	0.0115
V.	3.16	69.50	3.48	1.830	141	0.0117
VI.	3.75	94.60	3.73	1.999	145	0.0116
VII.	4.62	138.00	4.18	2.309	150	0.0115
Series of December, 1897. Charleston Pumping Station.						
I.	2.91	45.67	2.97	1.540	107	0.0149
II.	3.29	56.14	3.16	1.650	111	0.0147
Series of November, 1897. East Boston Pumping Station.						
I.	2.15	30.13	2.55	1.280	123	0.0126
II.	2.74	47.75	2.90	1.560	127	0.0127
III.	3.19	62.05	3.06	1.762	126	0.0129
IV.	3.20	64.82	3.18	1.771	131	0.0126
Series of June, 1900. Charleston Pumping Station.						
I.	2.29	30.82	2.66	1.342	102	0.0151
II.	2.78	41.39	2.86	1.508	104	0.0152
III.	3.26	52.96	3.04	1.645	106	0.0152
Series of April, 1900. East Boston Pumping Station.						
I.	1.99	24.96	2.38	1.120	119	0.0130
II.	2.83	48.26	2.82	1.606	121	0.0132
III.	3.64	76.78	3.16	1.952	124	0.0133
IV.	4.18	95.84	3.30	2.130	124	0.0136

In July, 1896, the system at these points had been in operation about 10 months, and the masonry was in almost its original condition. The sides of each sewer, above and below the average water line, were covered with a thin coating of grease of a leaden color, and supported an organic growth—probably of a fungus nature, as probably no light ever entered the sewer, except temporarily.

The condition of the sewers in November and December, 1897, after a continuous service of 2 years and 2 months, was similar to that at the time of the 1896 observations. There were slight incrustations at frequent intervals, due to barely visible seepage of ground-water, and the growth, though not much heavier, covered a greater area on the sides of the sewers.

The condition of the channels in April and June, 1900, after a continued use of 3 years and 9 months, was not much different from that which obtained during the 1897 observations. The incrustation seemed to be slightly greater, but the organic growth did not show any marked increase over that present in 1897.

A discussion of any observations such as these should be made with caution, and the following remarks are offered more as suggestions than as the writer's views. It will be seen, first, from a hydraulic standpoint, that the results of the individual observations of any one series show a slight lack of uniformity, and, when compared according to values of n, do not arrange themselves in any definite order. This may be due to slight inaccuracies, from various sources, in dealing with a fluid of the nature of sewage; or to relative variations in the condition of the internal surfaces at the different depths of flow; or, perhaps, to the variation in the composition of the sewage itself. However this may be, it is found that if the different series themselves be compared, these slight differences fade in importance, and the results show a much greater uniformity. This is illustrated more clearly in Table No. 2, which gives the average values of n, in the three series, for each channel, arranged in the order of time.

TABLE No. 2.—VALUES OF n FOR THE CHARLESTOWN AND EAST BOSTON CHANNELS.

Year.	1896.	1897.	1900.
Charlestown channel	0.0131	0.0148	0.0152
East Boston channel	0.0117	0.0127	0.0133

If the results in Table No. 2 be plotted, as shown in the diagrams on Fig. 1, with the horizontal scale representing time intervals from the date of opening of each system, and the vertical scale representing the tabulated values of n, and a curve be sketched through them, we might generalize as follows:

(1) Both curves are similar; the Charlestown channel curve being the steeper, and indicating a greater change in internal friction.

(2) Both curves show a sharp rise near the origin, indicating that the greatest change in internal surface took place soon after the channels were put in operation.

(3) That if the curves be projected back to the vertical axis, they show roughly the same initial coefficient of friction n, between 0.010 and 0.011, the Charlestown channel giving slightly the higher value.

In comparing these changes in the values of n with the actual condition of the channels, it should be kept in mind that the East Boston channel is of 3 ft. greater diameter than the Charlestown channel, that the invert of the East Boston channel is approximately 3 ft. above mean low water, while the Charlestown channel is 4 ft. below mean low water, and that the East Boston channel receives relatively less storm water than the Charlestown channel, and is, consequently, subject to less fluctuation of water surface. The importance of this last influence is evident from the fact that the deposit of both grease and organic growth appeared in greater abundance on the sides of the channels, and was greatest near the line of average flow. On the bottom of the channel there was practically no deposit; resulting, no doubt, from the scouring action of sand and other heavy particles transported along the invert by the sewage. This last feature is by no means novel, and has frequently been observed, though to a less extent, in water-supply conduits.

The effect of the density of the sewage upon the carrying capacity of these channels appears to be slight, in view of the fact that the observations were made under all the varying conditions of storm and dry-weather flow. The possible effect of cleaning or scraping, however, might be much greater, but, at this date, no cleaning of any sort has taken place in these channels. Such questions, with others of equal interest, will, it is hoped, have more light thrown upon them by the future continuance of this work.

Vol. XXVII. JANUARY, 1901. No. 1.

AMERICAN SOCIETY OF CIVIL ENGINEERS.
INSTITUTED 1852.

PAPERS AND DISCUSSIONS.

NOTE.—This Society is not responsible, as a body, for the facts and opinions advanced in any of its publications.

THE PRESERVATION OF RAILWAY TIES IN EUROPE.

Discussion.*

By Messrs. WARD BALDWIN and HORACE J. HOWE.

WARD BALDWIN, M. Am. Soc. C. E.—Mr. Chanute's exhaustive *résumé* of the present practice in Europe in the preservation of wooden railway ties suggests to the speaker what is generally regarded as the next step in the evolution of railway track, namely, the use of metal ties. It is true, in general, that, as the cost of timber increases, it becomes more economical to use, first, preserved ties, and then, metal ties. Now, the statistics presented in the paper show that in Europe preserved ties can be procured at a cost which would apparently make them more economical than metal ties. It is nevertheless true that metal ties are used extensively there. The observation of the speaker, in passing over many miles of European roads laid with metal ties, is that the riding qualities of a track with metal ties are not superior to those of a track with wooden ties; and, therefore, the reason for their use would not appear to be that they give a smoother track. A comparison of the practice in Europe in the use of creosoted ties and in the use of metal ties, now that the latter have been in extensive and growing use there for a number of years, would be interesting, and it is hoped that Mr. Chanute may add to his paper a discussion of this feature. Mr. Baldwin

*Continued from December, 1900, *Proceedings*. See September, 1900, *Proceedings*, for paper on this subject by Octave Chanute, Past-President, Am. Soc. C. E.

Mr. Howe. HORACE J. HOWE, M. Am. Soc. C. E.—The author shows, among other things, how ties are seasoned before treatment in Europe, and emphasizes the necessity for so doing in any and all of the processes which he mentions.

Possibly, seasoning for treatment is one thing and seasoning for direct track use is another. That is, the more the wood is made susceptible to the antiseptic, the better are the results, within certain limits; while the less alteration the surface undergoes, in the other case, the better will the tie stand the weather afterward.

It seems reasonable, therefore, to insist that even more care should be taken, in the latter case, to protect ties held over a season, from one cause or another, by the railroad company.

It is not uncommon to see bricks roofed over after receipt from the yard, and if that is considered economy by private concerns, why should not covering ties be economy for corporations? Bulk for bulk, the cost is about the same.

As to the saving by preserving ties, it is evident that everyone must calculate for himself. At present prices, the wolf does not seem to be at the door.

Assuming that a raw tie will last 9 years in first-class ballast (and no railroad hereabouts would consider seriously the treatment of ties unless its ballast was approximately first class), and that a treated tie will last 18 years, the following figures may serve as a basis for comparison:

One raw tie in place, 60 cents + 20 cents =	$0.80	
Interest at 4%, compounded annually for 18 years	0.82	
One raw tie in place, 60 cents + 20 cents =	0.80	
Interest for 9 years	0.34	
Total cost to maintain one raw tie for 18 years		$2.76
One treated tie in place, 60 cents + 50 cents + 20 cents =	$1.30	
Interest at 4% for 18 years	1.34	
Total cost to maintain one treated tie for 18 years		2.64

Roughly speaking, the costs are the same. No allowance is made for tie-plates. The item for treatment (50 cents) includes extra freight on that account.

If the foregoing does not focus with the facts, it is hoped that the author will indicate the reason.

Vol. XXVII. JANUARY, 1901. No. 1.

AMERICAN SOCIETY OF CIVIL ENGINEERS.

INSTITUTED 1852.

PAPERS AND DISCUSSIONS.

NOTE.—This Society is not responsible, as a body, for the facts and opinions advanced in any of its publications.

THE THEORY AND PRACTICE OF PRECISE SPIRIT LEVELING.

Discussion.*

By Messrs. W. S. WILLIAMS, J. A. OCKERSON and C. L. CRANDALL.

Mr. Williams.

W. S. WILLIAMS, Esq.† (by letter).—This paper presents every detail of precise spirit leveling with clearness, and points out in a scientific manner those features wherein some of the older methods of precise leveling are at fault and introduce errors into the work. The paper also gives to the profession many facts which good observers have known for some years but have kept to themselves. In some cases, however, the author has made deductions from too few observations, and made a few statements which, with a larger experience in this line of work, he would not have been likely to make.

Rods.—The author is undoubtedly correct in the reasons given for the superiority of self-reading over target rods, and the writer would add one other reason why a self-reading rod is superior to a target rod: An observer is inclined to take longer sights with a target rod than with a self-reading rod, because he is prone to think he can bisect a target at long distances; whereas, if he has to estimate millimeters on a rod graduated to centimeters, he will not take such long sights. The writer's experience has been that short sights are conducive to accurate work.

Foot-Plates.—Not many experienced observers will agree with the author that foot-plates are entirely out of date. As to whether pins

* Continued from November, 1900, *Proceedings*. See September, 1900, *Proceedings* for paper on this subject by David A. Molitor, M. Am. Soc. C. E.

† Surveyor in charge of Precise Leveling, Mississippi River Commission.

Mr. Williams. or foot-plates are the better for rod supports depends on the nature of the ground over which the levels are run. In stiff clay soils, grass roots, wooded lands full of roots and leaf mould, pins are the better; but for very sandy soil, railroad embankments of sand, or sand and gravel, and on hard roads and pavements, foot-plates are the better supports.

Refraction.—The author seems to have underrated the errors due to refraction as he says (page 839)*:

"Since it changes slowly and with some degree of regularity, and is noticeable only on comparatively long sights (500 m. or more), little or no appreciable effect is produced thereby on level readings unless a considerable time elapses between taking back and foresight readings late or early in the day."

Under some conditions, changing refraction will affect the readings very materially, even on sights as short as 50 m. Late in the afternoon on a sunny day the earth sometimes cools very rapidly. At such times the refraction becomes very erratic, and changes rapidly. A rod reading will change as much as 2 mm. in a very short time. Under such conditions an observer must wait until the air steadies down, turning from one rod to the other until he is sure to get both sights under uniform conditions; or, it may be that he will have to quit observing altogether. A light drifting fog will cause large and sudden changes in refraction. Passing clouds on a warm sunny day cause sudden changes in refraction, which must be guarded against. When the line of sight passes over a ravine through which cool air is moving, the reading is very much affected by refraction. If the line of sight passes near the ground on one sight and high above the ground on the other, the error due to refraction will be considerable if the sun is shining, and such conditions are to be avoided, or the sights must be very short. This applies particularly to leveling on a steep grade.

A change in the temperature of the air, from any cause whatever, will cause a change in the refraction, and an observer should be constantly on the lookout for such changes between the back and fore sights.

Collar Inequality.—The old method of determining the error due to collar inequality is undoubtedly correct, the author's attempted demonstration to the contrary notwithstanding; but the writer has found it necessary, in using this method with a Kern instrument, to firmly support the ends of the bar directly under the wyes, and not depend wholly on the vertical axes to keep the wyes perfectly fixed while the telescope is reversed. This can be done very easily and quickly by driving large spikes to the required height, into the top of a large stump or other stable structure.

The author's new method of determining the error due to inequality of collars would be all right if he had not neglected to take into

* *Proceedings*, Am. Soc. C. E., Vol. xxvi, October, 1900.

account errors due to refraction and due to the curvature of the earth when taking unequal sights. In the example given, the error due to curvature is 0.55 mm., and makes the constant error due to inequality of collars + 0.0544 mm. instead of +0 0624 mm. per meter. Mr. Williams.

Methods of Observing.—There can be but one objection urged against the author's method of observing, namely, that it requires about one-half more time than other methods which are just as good, as far as eliminating instrumental errors is concerned.

Equalizing the sights eliminates all instrumental errors and errors due to curvature and constant refraction more completely than any other process; hence, there is nothing gained by reversing the striding level and inverting the telescope in order to eliminate errors of inclination and collimation a second time, especially as it is extremely doubtful if these manipulations can always be made perfectly with any precise level.

The author's method gives double the number of observations, as compared with the ordinary method, and should, therefore, more completely eliminate errors of pointing and estimation, and give better results, if there are not other errors introduced by increasing the time of observation.

It is generally conceded that there are certain small errors due to changes in temperature of the different parts of the instrument during observations and to the change in temperature of the earth, such as the rising and settling of the rod supports and the instrument. Now, these errors will be increased in proportion as the time at each instrument station is increased, so that the method which will reduce the time of observation at each instrument station to a minimum, and thus allow the stretch to be run in the shortest time, is the best, so far as reducing the errors due to temperature is concerned.

Following the methods used by the Mississippi River Commission, the average time required to walk between stations, set up the instrument, and take the readings, is about 5 minutes, under average conditions; whereas, the author's method requires from 7 to 9½ minutes for each station. The progress, therefore, will be about 1½ miles per day by the former method and 1 mile per day by the latter, and the author's method would increase the cost per mile about one-half.

The author is undoubtedly correct in stating that all errors should be eliminated by the observations themselves as far as possible, as few errors remain constant, and, therefore, corrections for these cannot be applied to results with any degree of accuracy.

During the season of 1900, two precise-level parties ran 230 stretches on the Upper Mississippi River, and the sights were kept so nearly equal that a correction for errors in collimation, inclination and inequality of telescope collars was applied to only four results, and in each case the correction amounted to only 0.1 mm., so that the results

Mr. Williams. would not be appreciably affected if these corrections had been neglected altogether.

Rapidity.—The progress made by the parties working under the Mississippi River Commission for the past three years may be of interest when comparing methods, accuracy of work, etc.

The limit of closure on the following lines was fixed at 3 mm. $\sqrt{2L}$, L being the distance run between bench-marks, in kilometers. There were two parties working together, taking alternate sections of the line, on all this work except the line from St. Paul to Aitkin, Minn., where the writer had a single party. The time given includes all the days the parties were in the field, Sundays and holidays excepted; days lost by rain or otherwise are not deducted. The distances given refer to completed work, and always represent a double line, and in some cases more, where the line, on first trial, failed to close inside the limit.

TABLE No. 32.

Stretch.		Year.	Number of miles run.	Time, in days.	Average number of miles per day.	Average number of miles per day for each party.	Probable error per kilometer, in millimeters.
From	To						
Baton Rouge, La..	Mouth of South Pass..	1897-8	235	89	2.64	1.32	±0.68
Ft. Adams, Miss...	Baton Rouge, La....	1900	170	62	2.74	1.37	±0.62
New Orleans, La..	Biloxi, Miss.....						
St. Paul, Minn.....	Aitkin, Minn.....	1898	222	136	.....	1.63	±0.54
Brainerd, Minn....	Lake Itasca.....	1900	204	67	3.05	1.52	±0.59
Cass Lake, Minn..	Grand Rapids, Minn.						

The probable errors in the foregoing lines were computed by the formulas given in the paper (page 891).

Cost.—The cost per completed mile of the foregoing lines, where the data are available, is as follows:

New Orleans to Biloxi.....	85 miles.....	$16.00	per mile.
St. Paul to Aitkin	222 "	13.85	"
Brainerd to Lake Itasca... / Cass Lake to Grand Rapids	204 "	16.73	"

This estimate includes all items of expense, traveling expenses, express on instruments, bench-marks, etc., except cost of instruments and outfit.

The tile and pipe bench-marks, with brass caps, used by the Mississippi River Commission, cost about $3 each, delivered.

As the traveling expenses and express or freight charges are determined by the locality of the work, and are the same in any given case,

regardless of the number of miles run, and as the cost of bench-marks depends on the kind and number used, an estimate of cost per mile, leaving out these items of expense, would be of more value to the engineer in making estimates of cost for proposed lines of levels. Leaving out these items the cost per mile for the lines already given would be $15.50, $12.65 and $15.25, respectively, in the order given. Mr. Williams.

J. A. Ockerson, M. Am. Soc. C. E. (by letter)—This paper is very comprehensive, and Mr. Molitor deserves great credit for the exhaustive manner in which he has treated the subject. Mr. Ockerson.

The Mississippi River Commission has carried a line of precise levels from Itasca Lake, at the source of the Mississippi River, to the end of the Eads Jetties, at the mouth of that river. Side lines have also been run from Fulton, Ill., to Lake Michigan, at Chicago, and from St. Paul, Minn., to Lake Superior, at Duluth—a total length of something like 3 000 miles. Many of the features now recognized as good practice have been developed in this work.

The surface and sub-surface bench-marks were devised by the writer in 1882, and their utility is best shown by the fact that no material change has been made in them since they came into use. The necessity of having durable marks at frequent intervals was soon apparent. A few years' experience demonstrated that massive buildings settled, and natural ledges of rock disintegrated from frosts and sometimes were quarried for various purposes. Stone posts, projecting a foot or more above the surface, are easily destroyed by a blow or by forest fires. If the stone projects but slightly above the surface of the ground it is soon obscured by deposits of mud or other debris.

With these difficulties developed by experience, it was endeavored to substitute a mark which would obviate as many of the foregoing defects as possible.

The bench-mark adopted consists of a sub-surface vitrified tile 18 x 18 ins. x 4 ft., its upper surface marked by a suitable inscription which identifies it beyond question. A copper bolt projecting slightly above the surface of the tile is leaded into the center. This tile is placed from 3 to 4 ft. below the surface of the ground.

On the tile, and concentric with the copper bolt, is placed a 4-in. wrought-iron pipe 5 ft. long. The lower end of the pipe is flanged or flaring to prevent its being pulled up; the upper end is covered with a bronze cap fastened with a bolt, or, sometimes, riveted. The surface of the cap is also marked with suitable inscriptions, and has a center projection defining the exact point of elevation or location.

This type of surface mark has been copied by the United States Geological Survey, which obtained detailed drawings from the writer, and also ordered a large quantity from the firm making them for the Mississippi River Commission.

Mr. Ockerson. The practice, with the Commission, is to place upon the cap of the survey mark the latitude, longitude and elevation above sea level; so that any engineer or surveyor who wishes to use one of these marks has all the information before him.

The advantages of this mark are, the practical indestructibility of the tile, its large bearing surface, as compared with its weight, and the ready manner in which it can be profusely marked before burning. The pipe serves as an admirable witness mark, which can be used at all times, unless it shows signs of disturbance, in which case the cap can be removed and the tile reached through the pipe.

In the earlier work of the Commission, the limit of error was fixed at 5 mm. $\sqrt{2L}$, in which L is the distance run between bench-marks, expressed in kilometer units.

The limit of 3 mm. $\sqrt{2L}$ was fixed by the writer in instructions to precise level parties in 1892, and has been the prescribed limit ever since that time. On the whole, all of the mark lies well within even this limit.

The results of this very large experience in precise level work show that accurate work requires that the time interval between fore and back sights should be reduced to the shortest practicable limit, in order to avoid the effects due to temperature changes in the instrument, changes in refraction, in rod supports, etc. Hence the trained observers on this work will hesitate in accepting the author's method of reversals in observing (which serve to more than double the ordinary time interval) for the purpose of eliminating slight discrepancies which are already practically eliminated by equal back and fore sights.

The author and several who have contributed to the discussion make frequent mention of the leveling done by the Engineer Corps, but fail to mention the work of the Mississippi and Missouri River Commissions, both of which have done a large amount of high-grade work.

It is only just to say that the Assistant Engineers of the Mississippi River Commissson were the pioneers in the development of methods of precise leveling which are to-day recognized as the standard for high-grade work.

These methods, coupled with the improved instruments designed by the Coast Survey, will doubtless mark another step toward accuracy and economy in precise leveling.

Mr. Crandall. C. L. Crandall, M. Am. Soc. C. E. (by letter).—In discussing leveling instruments the author objects to the French government level, Plate XXXV, on account of the complicated method of reflecting the light from the ends of the level bubble to the observer by means of prisms, and on account of lack of delicacy of the instrument as a whole.

He incorrectly states that in reversing the level the prisms over the level must be refocused. There is no adjustment for focus, and the frame carrying the upper prisms simply requires turning 180° about a vertical axis. This requires no more labor than rotating the mirror used with the other types, while both ends of the bubble are seen near together, so that they can be carefully compared by moving the eye about 1 in. to the left, and looking in the same direction as through the telescope. Mr. Crandall.

The milled head shown at the right of the upper prisms on Plate XXXV, is connected to a pinion which engages with a rack from each prism, so that the distance between them can be changed symmetrically, with reference to the center, for different lengths of bubble.

In computing the sensitiveness of the level tube the author has apparently made a mistake and drawn erroneous conclusions. In Table No. 4, page 824,* he gives, as the result of Reinherz's experiments, the mean error of centering a bubble in a tube with 9-second divisions spaced 2 mm. apart, as 0.27 second, and for 2.7-second divisions, with the same spacing, 0.135-second, or one-half as much. He then computes the corresponding rod uncertainties at 100 m. as 0.5 and 0.1 mm., respectively (one being five times the other), and condemns the first as being beyond the allowable error of closure for the distance, and accepts the second as being about equal to the error of reading the rod.

The rod uncertainties, computed from the angles, would be:

$$0.27 \times \sin. 1 \text{ second} \times 100\,000 = 0.13 \text{ mm.};$$
$$0.135 \times \sin. 1 \text{ second} \times 100\,000 = 0.07 \text{ mm.};$$

the first double the second, as it should be, but fairly near the error of reading, as stated above. On page 796, however, the error of reading the Kern rod, graduated to centimeters, is given at from 0.2 to 0.5 mm., for distances up to 80 m , with a magnifying power of 50, as a minimum seldom reached by the best observers.

The 8.26-second level divisions of the French instrument thus do not make so bad a showing.

It is claimed by Messrs. Claye and Lallemand,† in support of the constants adopted for the French instrument, that the small but continual changes of temperature produce in the different parts of the instrument alternate expansions and contractions which put the bubble in a perpetual condition of instability, and render its centering at any instant difficult and uncertain, especially when the radius of curvature exceeds 60 m.

They estimate that the probable error of a rod reading, due to uncertainty in centering the bubble, is 0.1 mm. at 50 m., or 0.15 mm. at 75 m.

---

* *Proceedings*, Am. Soc. C. E., for September, 1900.

† *Encyclopédie des Travaux Publics. Lever des Plans et Nivellement.* Paris, 1889.

Mr. Crandall. As to magnifying power, they claim that the weight of the instrument increases about as the cube of the power, and that when the power exceeds 30, the weight easily reaches 17 to 20 kgr. Moreover, the atmospheric vibrations in the lower strata, due to thermal changes, frequently cause so much movement of the image of the rod as to render uncertain the estimates of the fractions of a division; an excess of magnifying power will only increase this difficulty. A power of 25 is used, as compared with 50 for most of the instruments of Table No. 1, but the object glass is nearly as large as any on the list.

With this power, they claim to be able to read the French rod, graduated to centimeters, with a probable error of 0.33 mm. at a distance of 75 m., or as accurately as the author states that the Kern rods can be read with a power of 50.

They also claim that experience has shown that the errors due to instability of temperature, in their total effect, are at least as great as those of reading the rod.

This makes the probable error for a sight,

$$r = \sqrt{0.15^2 + 0.33^2 + 0.33^2} = 0.5 \text{ mm.};$$

and for a set up for a mean of the two sets of readings,

$$r_1 = \frac{r}{\sqrt{2}}\sqrt{2} = 0.5 \text{ mm.}$$

On page 829 the author states that, in the commonly accepted method of determining the inequality of collars, the telescope and level are both reversed for the second reading; and that the difference of inclination as given by the bubble, whether the level is in adjustment or not, will be four times the angle between the axis of the collars and the elements of the cone enveloping the collars. Fig. 14 is referred to in proof of the statement, but in the figure the level tube is shown to be in perfect adjustment, *i. e.*, the zero point of the curved tube is the highest point when the top line of the telescope is horizontal. Had the figure been drawn otherwise it would not have been so convincing. In fact, it is difficult to see how, when the legs of the level are kept in position on the collars of the telescope, and all reversed, the shape or size of the upper portions of the collars can have the slightest effect upon the reading of the bubble, the collars simply forming extensions to the legs of the level as if permanently attached to them; the 3.5 divisions out of level, shown in the example on page 830, simply indicating that the level with its extended legs was one-half that amount out of adjustment.

The ordinary method referred to consists in taking a direct and reverse reading of the bubble, before and after changing ends with the telescope, or, in taking all the readings without reversing the level, since only the difference in inclination for the two positions of the telescope is required.

Mr. Crandall.

The assumptions as to the shape of the collars, the objections to the method, etc., stated on page 830, have been so fully discussed by Mr. Hayford, pages 1146–1148,* that no further mention will be made of them here. The paper, as a whole, is a valuable treatise upon the subject of precise leveling.

* *Proceedings*, Am. Soc. C. E., for November, 1900.

AMERICAN SOCIETY OF CIVIL ENGINEERS.

INSTITUTED 1852.

PAPERS AND DISCUSSIONS.

NOTE.—This Society is not responsible, as a body, for the facts and opinions advanced in any of its publications.

SOME PECULIAR RAILROAD BRIDGE ACCIDENTS.

Discussion.*

By JOSEPH MAYER, M. Am. Soc. C. E.

Mr. Mayer. JOSEPH MAYER, M. Am. Soc. C. E.—The pin-connected bridges described in the paper had a remarkable experience, and behaved certainly much better than their most enthusiastic advocate would venture to hope.

It is a curious fact that, while rigid connections are becoming the fashion in this country, they are abandoning them in Germany. The Rhein Bridge, in Worms, is an instance where, for the purpose of avoiding the secondary strains due to the loading of one track only, and the consequent larger deflection of one truss, the floor is freely suspended from the trusses above. The top struts are practically hinged, and there are no intermediate vibration bracings. The stringers have sliding connections to the floor beams to prevent the bending of the latter.

It cannot well be doubted that the secondary strains, which are very large in some members, like end suspenders and vertical posts with floor beams riveted between, could be largely reduced or altogether avoided by such connections. The speaker believes that the movement against hinges which is now in vogue in this country will be abandoned after trial and experience of the large secondary strains caused thereby.

* This discussion (of the paper by J. I. Boggs, Assoc. M. Am. Soc. C. E., printed in the *Proceedings* for November, 1900) is printed in *Proceedings* in order that the views expressed may be brought before all members of the Society for further discussion.

Communications on this subject received prior to February 23d, 1901, will be printed in a later number of *Proceedings*, and subsequently the whole discussion will be published in *Transactions*.

AMERICAN SOCIETY OF CIVIL ENGINEERS.

INSTITUTED 1852.

PAPERS AND DISCUSSIONS.

Note.—This Society is not responsible, as a body, for the facts and opinions advanced in any of its publications.

THE PRACTICAL COLUMN UNDER CENTRAL OR ECCENTRIC LOADS.

Discussion.*

By Albert I. Frye, M. Am. Soc. C. E.

Albert I. Frye, M. Am. Soc. C. E. (by letter).—The author's assumption that a deflected column will assume a parabolic curve when subjected to an eccentric loading is fairly correct and allowable. It will be, as he states, somewhere between a curve of sines and a circle, depending on the amount of eccentricity. Mr. Frye.

The writer found, several years ago, that for a beam loaded with a parabolic load W, in Fig. 53, the bending moments and the deflections will be nearly proportional to the sines of the respective angles; the ends of the beam corresponding to 0°, and the center of the beam to 90°. From this he obtained practically Euler's formula,

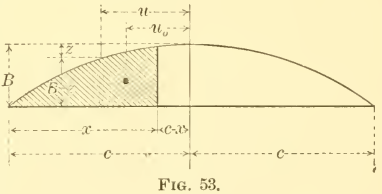


Fig. 53.

$$P = \frac{\pi^2 E I}{l^2}.$$

*Continued from November, 1900, *Proceedings*. See March, 1900, *Proceedings* for paper on this subject by J. M. Moncrieff, M. Am. Soc. C. E.

Mr. Frye. This demonstration is as follows:

Let W = total weight on the beam;
W_o = weight to left of section considered;
B = maximum intensity of load;
c = half span = $\frac{l}{2}$;
x = distance from end to section considered;
u_o = distance to center of gravity of load to left of section considered.

then, $$u_o = \frac{\int_{c-x}^{c} u\ (B - z)\ d\ u}{\int_{c-x}^{c} (B - z)\ d\ u} = \frac{12\ c^2 - 12\ c\ x + 3\ x^2}{12\ c - 4\ x}, \quad \ldots\ldots\ldots (1)$$

and when $$x = c,\ u_o = \frac{3}{8}\ c \ldots\ldots\ldots\ldots\ldots\ldots\ldots (1a)$$

$$W_o = \int_{c-x}^{c} (B - z)\ d\ u = \frac{B\ (3\ c\ x^2 - x^3)}{3\ c^2} \ldots\ldots\ldots\ldots (2)$$

and when $$x = c,\ W_o = \frac{2}{3}\ B\ c$$

or $$W = \frac{4}{3}\ B\ c \ldots\ldots\ldots\ldots\ldots\ldots\ldots (2a)$$

The moment at any section distant x from the end of the beam equals:

$$M_x = \frac{2}{3}\ B\ c\ x - \frac{B\ (3\ c\ x^2 - x^3)}{3\ c^2}\ (u_o + x - c).$$

Substituting the value of u_o in (1) and reducing,

$$M_x = \frac{B\ (8\ c^3\ x - 4\ c\ x^3 + x^4)}{12\ c^2} \ldots\ldots\ldots\ldots\ldots (3)$$

and when $$x = c,\ M = \frac{5}{12}\ B\ c^2 \ldots\ldots\ldots\ldots\ldots\ldots (3a)$$

The angle of slope of the deflected beam at any point distant x from the end equals:

$$i = \frac{1}{E\ I}\int M\ d\ x$$
$$= \frac{B}{12\ c^2\ E\ I}\left(4\ c^3\ x^2 - c\ x^4 + \frac{x^5}{5}\right) + k.$$

To find the value of the constant k,
when $$x = c,\quad i = o,$$
therefore, $$k = -\frac{B}{12\ c^2\ E\ I}\left(\frac{16\ c^2}{5}\right)$$

and $$i = \frac{B}{12\,c^2\,E\,I}\left(4\,c^3\,x^2 - c\,x^4 + \frac{x^5}{5} - \frac{16\,c^5}{5}\right) \ldots\ldots\ldots (4)$$ Mr. Frye.

when $$x = 0, \quad i = \frac{4}{15}\,\frac{B\,c^3}{E\,I} \ldots\ldots\ldots\ldots\ldots\ldots (4a)$$

The deflection of the beam at any point distant x from the end equals:

$$v = \int i\,dx = \frac{B}{12\,c^2\,E\,I}\int\left(4\,c^3\,x^2 - c\,x^4 + \frac{x^5}{5} - \frac{16\,c^5}{5}\right)dx$$

$$= \frac{B}{12\,c^2\,E\,I}\left(\frac{4\,c^3\,x^3}{3} - \frac{c\,x^5}{5} + \frac{x^6}{30} - \frac{16\,c^5\,x}{5}\right) + k_1$$

when $$x = 0, \quad v = 0; \text{ therefore } k_1 = 0,$$

and $$v = \frac{B}{12\,c^2\,E\,I}\left(\frac{4\,c^3\,x^3}{3} - \frac{c\,x^5}{5} + \frac{x^6}{30} - \frac{16\,c^5\,x}{5}\right) \ldots\ldots\ldots (5)$$

when $$x = c, \quad v = -\frac{61}{360}\,\frac{B\,c^4}{E\,I} \ldots\ldots\ldots\ldots\ldots (5a)$$

Dividing the half span c corresponding to 90° into six parts of 15° each, and calculating from (3) the bending moments at each section; calling the bending moment at the center of the beam unity, and likewise, using (5) for deflections; calling the deflection at the center of the beam unity, and comparing these results with the curve of sines, and the parabolic curve, gives the results shown in Table No. 6.

TABLE No. 6.

	0°	15°	30°	45°	60°	75°	90°
Bending moments	0	0.263	0.506	0.712	0.869	0.966	1
Deflections	0	0.262	0.501	0.707	0.866	0.966	1
Curve of sines	0	0.259	0.500	0.707	0.866	0.966	1
Parabolic curve	0	0.306	0.556	0.750	0.889	0.972	1

It will be seen on examination of Table No. 6 that the bending moments and the deflections correspond very nearly with the curve of sines of the theoretical deduction of Euler. As stated by the author, the actual curve will depart from the above ideal upon the application of an eccentric load on the column, and tend to conform more closely to the circle. By calculation, the writer has found that, for a deflection of unity at the center, in a column 480 units in length, the circle and the parabola are practically coincident. This would tend to show that, so far as the curve of the column is concerned, the assumption is on the basis of a preponderance of eccentric loading, since the latter, taken abstractly, would curve the column

Mr. Frye. to the arc of a circle, or practically a parabola. The assumption, therefore, is on the side of safety.

The bending moment at the center section of the column—Equations (3*a*) and (2*a*)—equals:

$$M = \frac{5}{12} B c^2 = \frac{5}{8} W_o c$$

$$= \frac{5}{32} W l \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (6)$$

If $M = \frac{f I}{y}$, then $f = \frac{5}{32} \frac{W l y}{I}$ ..... (6*a*)

The deflection at the center section of the column—Equations (5*a*) and (2*a*)—equals:

$$v = -\frac{61}{360} \frac{B c^4}{E I} = -\frac{61}{240} \frac{W_o c^3}{E I}$$

$$= -\frac{61}{3840} \frac{W l^3}{E I} \ldots\ldots\ldots\ldots\ldots\ldots (7)$$

From (6*a*), $W = \frac{32 f I}{5 l y}$, therefore $v = -\frac{61}{600} \frac{f l^2}{E y}$ ..... (7*a*)

Substituting this value of v in the general equation $M = P v$, and, omitting the minus sign, there is obtained:

$$P = \frac{M}{v} = \frac{\frac{f I}{y}}{\frac{61}{600} \frac{f l^2}{E y}} = \frac{600}{61} \frac{E I}{l^2} \ldots\ldots\ldots\ldots\ldots\ldots (8)$$

$$\frac{600}{61} = 9.836, \text{ whereas } \pi^2 = 9.87.$$

This proves that a lateral parabolic load W will produce practically the same curvature in a column as a direct concentric load P.

The paper is very valuable in presenting such a collection of tests, and so closely interpreting the causes of failure.

Vol. XXVII. JANUARY, 1901. No. 1.

AMERICAN SOCIETY OF CIVIL ENGINEERS.

INSTITUTED 1852.

PAPERS AND DISCUSSIONS.

NOTE—This Society is not responsible, as a body, for the facts and opinions advanced in any of its publications.

THE KINZUA VIADUCT OF THE ERIE RAILROAD COMPANY.

Discussion.*

By Messrs. GEORGE S. MORISON, R. S. BUCK and L. S. MOISSEIFF.

GEORGE S. MORISON, Past-President, Am. Soc. C. E. (by letter).— Mr. Morison.
The structure by which the old Kinzua Viaduct has been replaced, while containing much of the modern practice of detail connections and riveting, differs from other viaducts in two radical features. The first of these lies in the fact that the tops of the two battered posts of each bent are brought so near together, and are so rigidly connected, that the bent instead of being a quadrilateral is treated as an isosceles triangle. The second peculiarity is that all transverse diagonal bracing is omitted, the posts being stiffened only by their own unusually large transverse dimensions, assisted by the cross-struts and the rigidity of the connections between those cross-struts and the posts.

The first of these features is to be commended. The ideal trestle bent would be an isosceles triangle carrying a superstructure so narrow that the weight is all taken at a single point on top. While this cannot be done, the design of the new Kinzua Viaduct approaches sufficiently near to it for practical purposes. With bents of such

*This discussion (of the paper by C. R. Grimm, M. Am. Soc. C. E., printed in *Proceedings* for November, 1900) is printed in *Proceedings* in order that the views expressed may be brought before all members of the Society for further discussion.

Communications on this subject received prior to February 23d, 1901, will be printed in a later number of *Proceedings*, and subsequently the whole discussion will be published in *Transactions*.

Mr. Morison. moderate height that intermediate stiffening of the posts becomes unnecessary, this form of construction seems all that can be desired. There are, however, two very important limitations: The first of these is in height, new complications being introduced whenever transverse stiffeners are required; and the second is that it is only applicable to single-track structures, the eccentric loading of a double-track bridge producing irregular conditions at the top of the structure.

The second peculiar feature is of a more radical type. In the usual design each bent becomes a cantilever truss, standing vertically instead of horizontally, anchored, by weight or otherwise, to the masonry foundations, resisting a horizontal instead of a vertical load, and with its stiffness determined by the unit strains in the two chords and the distance between those chords. In the Kinzua design the cantilever form is retained, but the cantilever, instead of resisting horizontal forces for its whole length, resists them only at the top. The struts at the intermediate points are simply stiffeners, their only function being to control the curves of flexure of the posts. This flexure is naturally due to two causes: The first is wind; the second is the usual perversity of all compression members in buckling under loads, which perversity increases with the length of the member. Were the transverse struts connected to the posts by pins, their effect as stiffeners would be comparatively small, as the transverse deflections of the two posts would be represented by approximately parallel curves, the only effect of the stiffeners being to maintain the parallelism of these curves. Such struts would undoubtedly increase the stiffness of the posts, considered simply as compression members, but would add little to their ability to resist wind. In this case, however, the struts are rigidly attached to the posts, so that the angle made by the strut and the post must always remain constant. This introduces new conditions. If the struts were absolutely stiff (an impossible supposition) the direction of the posts at their points of intersection would always remain unchanged, but the posts of the lower part of each panel would bend from the wind on a curve whose center is on the leeward side, recovering their direction in the upper part of each panel by a curve whose center is on the windward side. As a moderate amount of flexure takes place also in the transverse struts, the actual bending in the lower part of the panel exceeds the recovery in the upper part of the panel. The result, on either supposition, is a series of cumulative deflections. The top of the lowest panel is deflected by an amount determined by the wind pressure and the stiffness of the posts. The second panel has its own similar deflection, but, as the base of the second panel is the top of the lower panel, the deflection of the top of the second panel is the sum of the two deflections; and so on to the top of the tower. The principle on which this structure appears to have been designed is that these

various bendings of the posts shall produce no strains beyond safe limits in the extreme fibers of those posts. It involves calculations of a complicated and abstruse character, but it is possible to design a structure in this way which is perfectly secure. Mr. Morison.

The frames on many tall office buildings have been designed on this principle, though in many instances the calculations have been of the most crude and careless kind. The portal of a through bridge is really a construction of the same order. This principle, however, has generally been used only in those places where there were serious objections to transverse diagonal bracing. The general practice indicates that there are good reasons why engineers have always preferred diagonal bracing when there were opportunities for putting it in. These reasons are of two kinds: First, with diagonal bracing and a base of sufficient width to prevent tension in anchorages, there is never any reversal of strains in the posts, and, furthermore, the strains caused by wind alone when distributed over the whole cross-section of the post produce very small unit stresses and very slight changes in lengths of posts. In the present design reversals of strains are likely to occur in the extreme fibers of almost every part of each post, and these involve an appreciable change in the form of the post. The second reason is that the stiffness of a beam or truss is in direct proportion to its depth, and, with the opportunity of giving a trestle bent a stiffness based on the whole width of its base, it does not seem right to accept a stiffness based only on the width of the post.

Bridge specifications, many of which are drawn with great care, generally have the defect of specifying strength and not providing for stiffness. Under such specifications two structures can be accepted as equally good, though, under a load, one of them will have twice the distortion that the other will have. For immediate safety, strength is all that is needed; for long life of structure, stiffness is at least equally important. This objection may be raised to some special forms of trusses, favored because of their economy of material, in which much greater variations occur in the strains of individual members than in differently designed trusses containing a little more metal. As compared with a viaduct of the usual design, everything would seem to indicate that the transverse deflections under strain, and even the distortion of the posts under compression, would be large in the new Kinzua Viaduct. If this be so, it is not probable that this design will be repeated. The objection to diagonal rods in the panels of such a viaduct, with pin and turn-buckle connections, is perhaps more theoretical than real, and, in a structure with the rigid and excellent details of the one described, they certainly could do no harm. It would be an interesting thing to put such rods in one of the tall towers of this viaduct, and then compare the stiffness of this tower and the adjoining tower whenever an extraordinary storm passes through the valley.

Mr. Buck. R. S. Buck, M. Am. Soc. C. E.—The Kinzua Viaduct is one of the best known and most unique railroad bridges in America, and its reconstruction will doubtless command general attention, both at home and abroad. This paper and the articles appearing in the leading engineering journals, while not furnishing data adequate to form a conclusive verdict as to the merits or demerits of the design, furnish sufficient ground for discussion of certain of its salient features. It is quite possible that a more thorough treatment of the subject by those fully acquainted with the design may disarm some of the following adverse criticisms; but the writer believes that the showing on which he is compelled to base his discussion fully justifies its character.

The author does not, in the writer's opinion, furnish such full explanation of his methods of calculation, nor as many details, as the radical character of the design demands.

The paper leaves so much to the ingenuity and imagination of the reader that it is as difficult to reach a full understanding of his methods and deductions as it is to find full justification for the design. The calculations are involved, and appear to be contradictory. The reader is subjected to much unnecessary trouble by the absence of a clear statement of the meaning of terms in the equations, limits of integration, and the steps by which the several expressions on pages 1080 and 1081* are reached.

The writer has been unable, despite persistent effort and some able outside assistance, to follow the calculations to a finish, but some points stand out in a measure independent of the statement of the general scheme, and can be judged as correct or otherwise.

On page 1075 appears the statement:

"The problem can also be stated to consist of finding the locations of the points of contraflexure, because, if these locations were known, it would only be necessary to resolve the resultant," etc.

This refers to the analytical treatment, but, beyond this statement, there is nothing discernable in the text, table of equations or stress diagrams, to indicate that any effort has been made by the author to find the true points of contraflexure or to place them anywhere else than arbitrarily at the centers of the members.

Referring to the graphical treatment on the stress diagram, page 1079, is the note: "The computation of wind stresses assumes the point of contraflexure at the middle of the column sections, portals and headers."

These two quoted statements conflict, and should be further explained, for, until they are, there is no logical sequence in what follows. It is quite possible that the points of contraflexure are not very far from the centers of the members in all cases except in the case of the bottom sections of the columns. Here, the assumption is materially erroneous, and the effect on the moments very considerable.

* *Proceedings*, Am. Soc. C. E., for November, 1900.

Mr. Buck.

In this case, the author not only assumes the column to be absolutely fixed at its foot, but also apparently ignores the bottom strut as resisting bending at this point. As a matter of fact, the fixity of the column at its foot is almost entirely dependent upon this strut.

The only other features that tend to fix it are the two $1\frac{1}{2}$-in. anchor bolts very near the center of the base, and the direct pressure on the column acting on its square end.

The anchor bolts, intended to resist only 12 000 lbs. direct tension, can do but little to resist bending in the column. With rollers under the leeward column and with direct pressure removed by up-lift on the windward column, due to the assumed wind load on the unloaded structure, the fixity of the columns due to direct weight is very uncertain.

In the opinion of the writer, the conditions do not justify the assumption of more fixity at the bottom of the columns than that furnished by the bottom strut. The correct location of the point of contraflexure of the bottom section is not far above the foot of the column, instead of at the center. The result of this is to greatly increase the bending at the level of Strut 1 over what is shown in the author's results, and also to increase the up-lift on the windward column enough to make it exceed the dead-load stress, with the assumed wind load on the unloaded structure.

The writer would like to know if the author means, by the closing paragraph of his paper, that if the moments of inertia of a group of members were doubled it would not materially increase the stiffness of the bent? Also, how many members he considers as "a group"?

The failure of the author to give the essential details of connections bearing on the peculiar features of this design renders it necessary, in order to even approach an adequate understanding of the subject, to have recourse to the articles on the same subject in the technical journals.* These articles appear to be based on data from an authentic source, and to bear the stamp of official sanction. It is therefore deemed proper to refer to these articles for information essential to an adequate discussion of the subject, but lacking in the paper. It is to be hoped that the author will furnish all these details, in order to render the paper complete within itself and to correct any error which may arise from having to go outside of the paper for information.

Assuming that the author's methods of calculation are reasonably approximate—which does not seem warranted until they are rendered logical and free from obscurity—there are still, in the opinion of the writer, faults in the design. He believes it is a mistake to reject the time-honored diagonal bracing in a structure of such proportions and to substitute a form of bracing which, even when most carefully and

* *Railroad Gazette*, Nov. 30, 1900, and *The Engineering Record*, Dec. 1, 1900.

Mr. Buck. generously detailed, could hardly be made both sure and economical. In all bridges, outside of a suspension bridge, rigidity is one of the prime objects to be attained, and especially in the case of railroad bridges. Substituting for direct stresses bending in members, being themselves certainly not possessed of a high degree of rigidity, is depriving the concrete structure of rigidity to an extent that seems questionable.

The height of this viaduct, at its highest point, is 285 ft. from masonry to base of rail. Each tower is independent, and can receive its maximum wind stress with wind over only about 150 ft. longitudinally of the structure. Within this narrow limit wind strikes in gusts and with considerable impact. In a tower so high, where 54% of the wind pressure is applied at the top when loaded, and 34% when unloaded, where the dead load is not sufficient to prevent up-lift on the windward column with assumed wind on the unloaded structure, the dynamic effect of vibration is a consideration that should be provided for. In a design of this kind, the amount of lateral deflection of the towers under wind load should be carefully ascertained, and, although the writer has made no calculation for this purpose, he deems it safe to venture the statement that it is much greater in this design than in the case where the ordinary form of bracing is used.

It would be a matter of great interest to know, from transit observations, just what the present structure deflects laterally under high wind.

The detailing of the lateral strut connections with the columns seems to the writer hardly in keeping with the heroic and uncertain service they have to perform. The use of clip angles to reinforce the attachment of the strut chords to the columns, applied so as to be almost wholly ineffectual, is not warranted by what appears to be the only consideration for so doing, namely, the saving of some weight in the gusset plates at these points.

The light character of the knee braces, and their method of attachment to the struts, seems to indicate that their function is ornamental rather than useful; yet, with sufficient metal and adequate attachment to the columns and struts, they could be made to add very materially to the strength and rigidity of the structure.

A study of these details goes far to explain the material saving in weight with which the author credits this design, for they bear evidence of scaling down the metal to an extent that can hardly be generally endorsed.

There is another feature of this design which, independent of the character of the lateral bracing, seems to lack due strength, namely, the $1\frac{1}{2}$-in. anchor bolts which, having served in the old structure, now serve in the new. In the old structure it is understood that there were no rollers under either column, temperature movements being taken

care of by slotting transversely the anchor bolt holes in the column shoes, thus permitting the shoes to slide on top of the piers. The bottom strut was probably bolted fast to the center pier. With the bridge unloaded there was a wind pressure of about 45 000 lbs. on each tower, or 22 500 lbs. on each bent, under the assumed wind loads on the unloaded structure. To resist this shear at the top of the piers, there being up-lift on the windward column, there was friction under the leeward shoe, the attachment at the top of the center pier and the shear of probably one pair of anchor bolts in the column piers. These connections, though somewhat uncertain because of the slotted holes, were doubtless adequate, especially as the friction under the leeward shoe alone was perhaps equal to the wind shear. Mr. Buck.

In the case of the new structure, the service demanded of these anchor bolts is much more severe. The shear is 55 600 lbs. to the bent, $2\frac{1}{2}$ times that in the old bridge. Rollers are placed under the column to leeward of the prevailing heavy gales, and there is therefore practically no frictional resistance at the foot of this column, and, the anchor bolt holes being slotted 6 ins. on this shoe, the bolts can take no shear from the shoe under normal conditions. It is also reasonable to assume that the anchor bolt holes in the bottom strut at the center pier were slotted. With the assumed wind load on the unloaded structure there is, as before stated, up-lift on the windward column. Therefore, with practically no friction under the shoe of this column the whole 55 600 lbs. of the wind shear has to be taken up by the two $1\frac{1}{2}$-in. anchor bolts in the windward pier. This seems to be more than should be exacted of such bolts, and it is difficult to understand how the use of the old bolts, without reinforcement, could be justified where the wind shear was so greatly increased and the means of resisting it so materially reduced. In short, the factor of safety of the anchorage of bents to piers is reduced at least $2\frac{1}{2}$ times, and, in addition, by the specific amount of friction lost under the leeward shoe.

The writer fails to see where any advantage is gained by placing the rollers on the side away from the direction of prevailing heavy winds, as the capacity of the towers to resist the shear due to such winds is thereby so greatly reduced.

The bolts in the movable shoe should be just as capable of resisting direct tension from up-lift as those in the fixed shoe, and there would be no loss of friction, but, in fact, a gain, when the fixed shoe is to leeward.

L. S. Moisseiff, Assoc. M. Am. Soc. C. E.—This paper offers so many novel features and distinct departures from the usual design of high viaducts in the best modern American practice that the discussion of its merits or defects should prove to be of considerable interest to the profession. Mr. Moisseiff

Mr. Moisseiff. While designed according to the rather conservative specifications of the Erie Railroad Company, the design of the high towers denotes a radical departure from the type used heretofore, in omitting the sway diagonals. The bending moments caused by the assumed wind loads are intended to be resisted by the increased stiffness of the columns and horizontal struts which are strengthened by brackets. Not that this method of providing for wind stresses is entirely unknown or untried; it has been used very frequently, and with some reluctance, for sway bracing of through bridges, for wind bracing of high steel-skeleton structures, and in all portals. But, in all cases where sway diagonals have been omitted, this omission has been due to lack of head room or due to wall space taken up by windows and doors, and was thus made compulsory by the necessities of the case.

It seems so much to be almost an axiom of good structural design never to resist by bending stresses what can be done as well by direct axial stress, that the application of the "portal bracing" principle in a high viaduct, subject to high wind pressures and having no limitations of head room, is surprising.

Every engineer who has had to design trusses and frames of great magnitude, and containing long members which require bracing and intermediate supports, knows the great amount of material required by these secondary members and how rapidly the percentage of material required to attain the practical design of the truss increases in comparison with the stress volume. Every attempt to reduce the cost of these secondary members is a step in the right direction; but it seems doubtful whether the saving in material claimed by the author for his design has been obtained without impairing the efficiency of the structure to resist lateral forces and vibrations, especially the latter.

While a comparison of the tower bracing as designed with the usual diagonal bracing of high trestles and towers with stiff members will certainly show a saving in weight for the portal-braced type, a comparison of their relative stiffness will be greatly in favor of the one with diagonal braces. A high trestle bent of the type used by the author is certainly not stiffer than the old tie-rod braced bent. In order to get a fair comparison between the portal-braced system and the system with diagonals, the former should be compared with a bent braced by tie rods. The writer believes that the claimed economy will then soon vanish. The bending moments induced by wind pressures may be provided for by the stiff and deep struts just as well as by rigid diagonals, but the vibrations caused by them will be considerably higher than in diagonally braced towers. The tower will, in fact, have some similarity to a tuning fork.

Mr. Moisseiff.

The author deserves credit for the application of modern methods to the analysis of the stresses. The principle of least work used by him is a handy and convenient tool for the determination of stresses in frames, and especially for the study of new types of trusses. The value of the author's analytic treatment would be greatly enhanced if the notation used and the processes gone through were stated more explicitly and carefully.

In his analysis the author assumes each frame to be fixed rigidly at the bottom. This assumption is erroneous. The two old wrought-iron bolts, of $1\frac{1}{2}$ ins. diameter and some 18 ins. apart, are not sufficient to insure the necessary degree of fixedness to the columns. Besides, the high bents have one leg on roller bearings, which is certainly not very conducive to the rigidity of the lower column end. But this assumption of fixed ends for the lower ends of the columns is a vital and extremely important factor in the author's theory. These ends are only in so far fixed as the bottom horizontal struts provide for, and not much more.

Instead of considering for a one-story bent, as the author does, the upper horizontal beam only, the correct way would be to take also the lower horizontal strut into account, and include its work of deformation in the general formula. The same idea should be followed through for all bents, always including the bottom horizontal strut as an essential member.

For a single-story bent the problem is quite simple. In view of the general application of this case for sway bracing and portals of bridges, a simple formula to find the points of contra-flexure of the columns will be given here which does not necessitate in its use the application of the higher calculus, and is rather handy.

Professor Winkler* deduces the same formula, and the following is a simplified deduction thereof by the principle of least work, as used by Mr. Grimm.

The work done by any beam subject to bending, in assuming its new position of equilibrium, is given by

$$A = \int \frac{M^2}{2\,E\,I}\,d\,x,$$

neglecting the work done by the axial force. E is here the modulus of elasticity, and I the moment of inertia of the beam in flexure. If the beam is fixed at both ends, Fig. 10, and is of length l, then the moment at any point x is

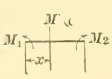


FIG. 10.

$$M = M_1 + (M_2 - M_1)\,\frac{x}{l}.$$

* "Querkonstructionen der Eisernen Brücken."

Mr. Moisseiff. In order to find the work done by the beam in attaining its new equilibrium, we substitute this value in the foregoing work formula:

$$M^2 = M_1^2 + (M_2 - M_1)^2 \frac{x^2}{l^2} + 2\, M_1 (M_2 - M_1) \frac{x}{l}$$

$$A = \int \frac{M^2\, d\,x}{2\, E\, I} = \frac{1}{2\, E\, I} \int_o^l \left[M_1^2 + (M_2 - M_1)^2 \frac{x^2}{l^2} + 2\, M_1 (M_2 - M_1) \frac{x}{l} \right] d\,x = \frac{l}{6\, E\, I} [M_2^2 + M_1^2 + M_1\, M_2.]$$

This holds true for any beam fixed at both ends by the moments M_1, M_2. This being given, the one-story bent can now be treated.

Fig 11 represents a frame of height h, and horizontal struts with fixed joints subject to the action of a horizontal force $2\ P$ at the joint 1. Let 0-0 denote the line of contraflexure, and h_1 and h_2 the distances from the points of contraflexure to the upper and lower struts, respectively. The total amount of deformation work caused by $2\ P$ consists of the sum of the work done by its four individual members.

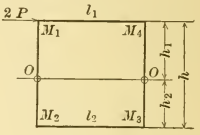


Fig. 11.

$$A = \frac{1}{6\, E} \left[\frac{h}{I} (M_1^2 + M_1\, M_2 + M_2^2) + \frac{l_2}{I_2} (M_2^2 + M_2\, M_3 + M_3^2) + \frac{h}{I} (M_3^2 + M_3\, M_4 + M_4^2) + \frac{l_1}{I_1} (M_4^2 + M_4\, M_1 + M_1^2) \right]$$

where I is the moment of inertia of the columns I_1 of the upper strut, and I_2 of the lower strut. For equilibrium, the work done will be a minimum.

The moments are:

$$M_1 = Ph;\ M_2 = Ph_2 = P\,(h - h_1) = Ph - M_1;\ M_2 = -\,M_2;\ M_4 = -\,M_1$$

Differentiating partially with respect to h_1 as the independent variable:

$$\frac{\delta\, M_1}{\delta\, h_1} = P;\ \frac{\delta\, M_2}{\delta\, h_1} = -\,P;\ \frac{\delta\, M_3}{\delta\, h_1} = +\,P;\ \frac{\delta\, M_4}{\delta\, h_1} = -\,P.$$

$6\ E$ and P, as constants, divide out, and we get:

$$\frac{\delta\, A}{\delta\, h_1} = 0 = \left[\frac{h}{I} (M_1 - M_2) + \frac{l_2}{I_2} (M_3 - M_2) + \frac{h}{I} (M_3\, M_4) + \frac{l_1}{I_1} (M_1 - M_4) \right]$$

Introducing the values set for the moments:

$$\frac{h}{I} (2\, h_1 - h) + \frac{l_2}{I_2} (h_1 - h) + \frac{l_1}{I_1} h_1 = 0,$$

whence,

$$h_1 = h\, \frac{\frac{h}{I} + \frac{l_2}{I_2}}{\frac{2\, h}{I} + \frac{l_2}{I_2} + \frac{l_1}{I_1}}$$

Mr. Moisseiff.

This formula gives the position of the point of contraflexure, and with it the moments at the four joints are readily found. It will be noted that the position of the points of contraflexure is independent of the external force, and that it is only a function of the moments of inertia of the members and their lengths. This might have been expected to be so.

For all the members of the same moment of inertia, and for the horizontal struts of the same lengths, $I_1 = I_2 = I$; $l_1 = l_2$, we find

$$h_1 = \frac{h}{2}$$

The point of contraflexure is at the middle of the column. Thus we find that the assumption that the point of contraflexure is at half the height of the columns is true only for a rectangle with sides having the same moment of inertia.

Applying the above contraflexure formula to the one-story bent taken by the author, the point of contraflexure will be almost 21.36 ft.

From the general equation of moments, as given by the author,

$$M = P_5\, z - X_5\,(h + n\, z).$$

For the point of contraflexure $M = P_5\, h_1 - X_5\,(h + n\, h_1) = 0$.

Whence

$$X_5 = \frac{P_5\, h_1}{h + h_1\, n} = \frac{6.7 \times 21.36}{4.765 + \dfrac{21.36}{6}} = 17.2 \text{ tons.}$$

The greatest moment at Joint 1, $M_1 = -\ X_5 \times 4.765 = -\ 81.85$ foot-tons.

$$M_2 = 37.6 \text{ foot-tons.}$$

A comparison of the author's figures shows the effect of his assumption of fixed ends. The point of contraflexure will naturally be farthest from the stiffer joint, and it actually moves down and thereby increases the moment on top by some 14 per cent. Of course, the lower bents, as designed by the author, are so massive that they offer more than ample resistance to any increased moments. But this is due to the allowed low working stress.

The lower horizontal strut is only 30 ins. deep, and its moment of inertia is less than one-twentieth of that of the upper 8 ft. deep strut. The point of contraflexure will, of course, move nearer to the lower end, and, making all due allowance for the stiffening effect of the brackets, it will be found to be 0.87 of the height of the lower story from the 8-ft. strut, or 52.7 ft. The sum of all the X-forces above the point of contraflexure, which is but the transferred wind load, will be 52.5 tons, and the maximum moment in the column will be 192.5 foot-tons, instead of 108.54 foot-tons as given by the author, or some 78% higher. The extreme fiber stress due to this moment in the columns is 7 000 lbs. per square inch.

Taking the stresses found by the author for dead, live, and wind

Mr. Moisseiff. load and omitting the traction stresses, and adding to them the extreme fiber stress due to bending, the greatest stress will reach 15 500 lbs. per square inch. This exceeds by 11% the maximum stress of 14 000 lbs. given by the author. Including traction, the stress will be 20 000 lbs.

It would appear from the paper that the lower bents are simply cut-off upper portions of the high bent, so that, for instance, in the four-story bent the 8-ft. horizontal strut forms the lowest member. If this is so, and if the author appreciated the great stiffening effect of the lower strut, why did he not put one as deep or deeper in the five-story bent, instead of the comparatively flimsy 30-in. strut? And if he deemed the bottom horizontal struts of no importance, as it results from his theory, then why did he not replace these deep bottom struts by the light ones used in the highest bent, and save material thereby?

Vol. XXVII. JANUARY, 1901. No. 1.

AMERICAN SOCIETY OF CIVIL ENGINEERS.

INSTITUTED 1852.

PAPERS AND DISCUSSIONS.

NOTE.—This Society is not responsible, as a body, for the facts and opinions advanced in any of its publications.

A DIRECT METHOD OF SPACING RIVETS AND FINDING THE POSITION, ETC., OF STIFFENERS IN PLATE GIRDERS.

Discussion.*

By Messrs. BERNT BERGER and F. W. SKINNER.

BERNT BERGER, Assoc. M. Am. Soc. C. E.—This paper is a valuable exposition of a graphical method of finding the exact spacing of rivets in flanges of plate girders under assumed loads and stresses. It is well worth careful study as it gives a clear insight into the variations in values and conditions of forces and stresses. The speaker has great faith and confidence in graphic statics, and uses that method quite extensively, but must differ with the author on the question of the applicability of the graphical method to the ordinary, every-day work of designing plate girders. The graphical method can at times be used to advantage in computations of railroad bridges for engine diagrams; but, for most of such cases, and especially for plate girders, the speaker has found, in his own work, that the analytical method, applied with the aid of the well-known moment diagrams, is much shorter and easier, especially when a slide rule is also used. For plate-girder bridges, as in the present case, it is, of course, necessary to find the end shear in the first place, and the shear at a very few intermediate points besides. For practical reasons, the rivet spacing in the flanges is constant for certain distances, and for shorter plate girders, therefore, all that is needed is the end shear and the shear at Mr. Berger.

*Continued from December, 1900, *Proceedings*. See November, 1900, *Proceedings*, for paper on this subject by E. Schmitt, Assoc. M. Am. Soc. C. E.

Mr. Berger. the quarter point. The 6-in. limit of rivet pitch will cover the shear in the middle half, especially when the rule about closer pitch in the flange which carries the track is also taken into account. For longer girders, up to 80 or 100 ft., the shear should be found at a few more points; but, with the aid of a moment diagram, this is readily and quickly done, more so, the speaker has always found, than by any graphical method.

The thickness of the web is determined by the required section of metal for shear and the necessary number of rivets. Shallow girders must have a thicker web, deep girders may have a thinner web. Each end stiffener must be able to take all the end shear in compression, but not necessarily as a column of length equal to the depth of the girder, as the web through the rivets distributes the shear over the end stiffener through its whole depth. The intermediate stiffeners cannot, according to the speaker's views, act as columns for the distribution of the shear over the web, as most of that shear is already in the web; but they can so act under concentrated loads, which are only part of the shear, as when engine loading for railroad bridges is considered. Thus, for girders which carry the track direct on one or the other of the flanges, the service which such intermediate stiffeners perform, consists then principally in holding the web in position—preventing it from buckling. But where, for instance, the stringers of a bridge rest on top of the floor beams, the stiffeners on the floor-beam web must of course serve to distribute the concentrated load over the web of the floor beam, and must have sufficient area for compression.

As to the axiom laid down by the author in the beginning of the paper, the speaker begs to say that, generally speaking, he thinks formulas little worth the effort of remembering. The thorough understanding of principles and methods, and their application, is of far greater importance, and to this end the paper is of great help.

Mr. Skinner. F. W. Skinner, M. Am. Soc. C. E.—A particularly interesting, and perhaps extreme, case of the application of the web stiffener system to a plate girder, and one which the speaker believes is not widely known, came under his observation recently.

In Cincinnati, Ohio, there is a plate-girder span of 213 ft.—the longest of this kind of which the speaker has ever heard. The bridge is formed of two main girders, each 16 ft. deep, which carry a 30-ft. roadway and two 10-ft. sidewalks. The thickness of the web could not be ascertained, but is not more than $\frac{3}{8}$ in., and, possibly, is not more than $\frac{3}{16}$ in. The structure has been in use more than thirty years, and the iron is badly corroded. The bottom chord is made with two small angles and several 42-in. horizontal flange plates. The top-chord is a three-web box section 42 ins. wide. The web is divided into panels of about 10 ft., and in each panel there are two

transverse stiffener plates, each 26 ins. wide, and each formed with a flange angle all around. Mr. Skinner.

Calculations may be possible as to how much that web, 16 ft. high and $\frac{5}{16}$ in. thick, would have stood without the stiffeners, and also how much it would stand with the stiffeners.

One peculiar feature was the way in which each panel of the web was built up of five pieces, 8 ft. high, butt jointed, and spliced with two cover plates.

Another peculiar feature of the bridge was the extreme generosity of the bearings on the abutments, each of which consisted of two very thick cast-iron plates about 7 ft. long; the upper one sliding between longitudinal flanges on the edges of the lower plate.

After many years' service, two intermediate steel trestle bents, each about 50 ft. from the center of the span, were put in to reduce the vibrations.

The whole construction is a curiosity, if not a monstrosity, but is still in active service, and is remarkable for its dimensions.

Rensselaer Polytechnic Institute,
Troy, N.Y.

ESTABLISHED 1824.
A SCHOOL OF ENGINEERING

Local examinations provided for. Send for a Catalogue

LOUISVILLE CEMENT.

The undersigned is General Agent for the following Standard Brands of Louisville Cement:

FALLS MILLS (J. Hulme Brand),
BLACK DIAMOND MILLS (River), Diamond Brand,
SPEED MILLS, Star Brand,
FALLS CITY MILLS, Anchor Brand,
BLACK DIAMOND MILLS (Railroad), Diamond Brand.

This Cement has been in general use throughout the West and South since 1830; most of the public works having been constructed with it. Orders for shipment to any part of the country, by rail or water, will receive prompt and careful attention.

Sales for 1892: 2,145,568 Barrels.

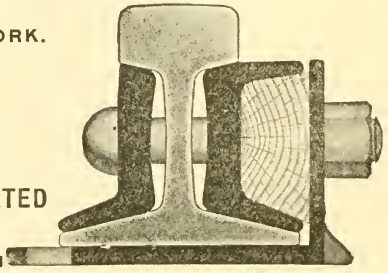
WESTERN CEMENT COMPANY,
247 W. Main St., Louisville, Ky.

The Weber Railway Joint Mfg. Co.

EMPIRE BUILDING,
71 BROADWAY, NEW YORK.
BRANCHES:
BOSTON, MASON BLDG.
CHICAGO, OLD COLONY BLDG.
BALTIMORE, EQUITABLE BLDG.

—o—

Manufacturers of
"T" STEP and INSULATED
JOINTS.



ESTABLISHED 1845.

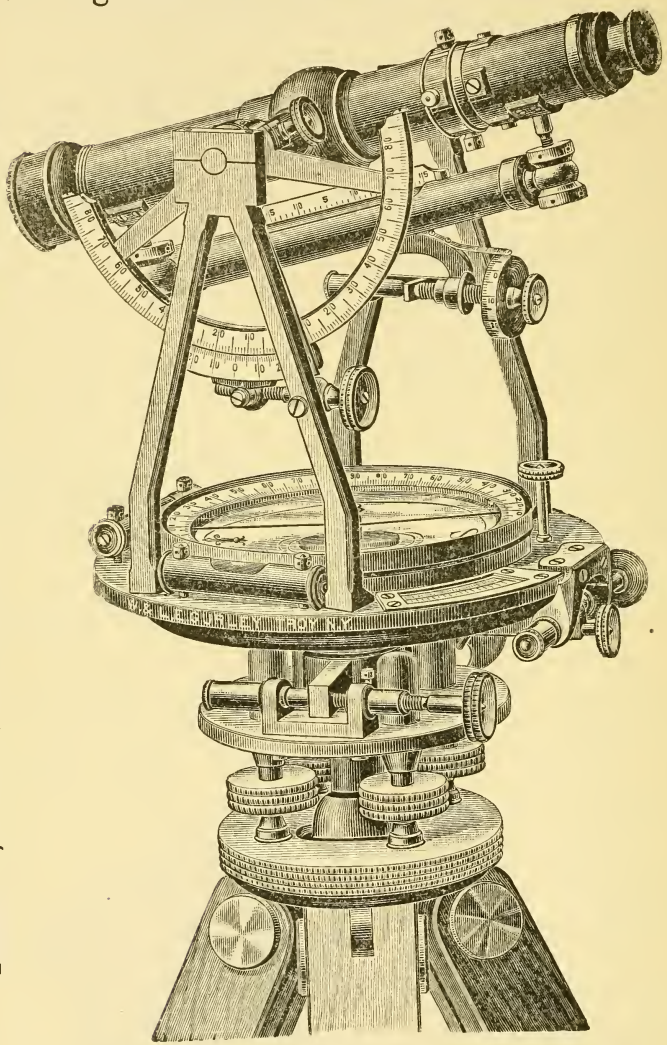
W. & L. E. GURLEY

TROY, N. Y., U. S. A.

LARGEST MANUFACTURERS IN AMERICA OF

Civil Engineers' and Surveyors' Field Instruments.

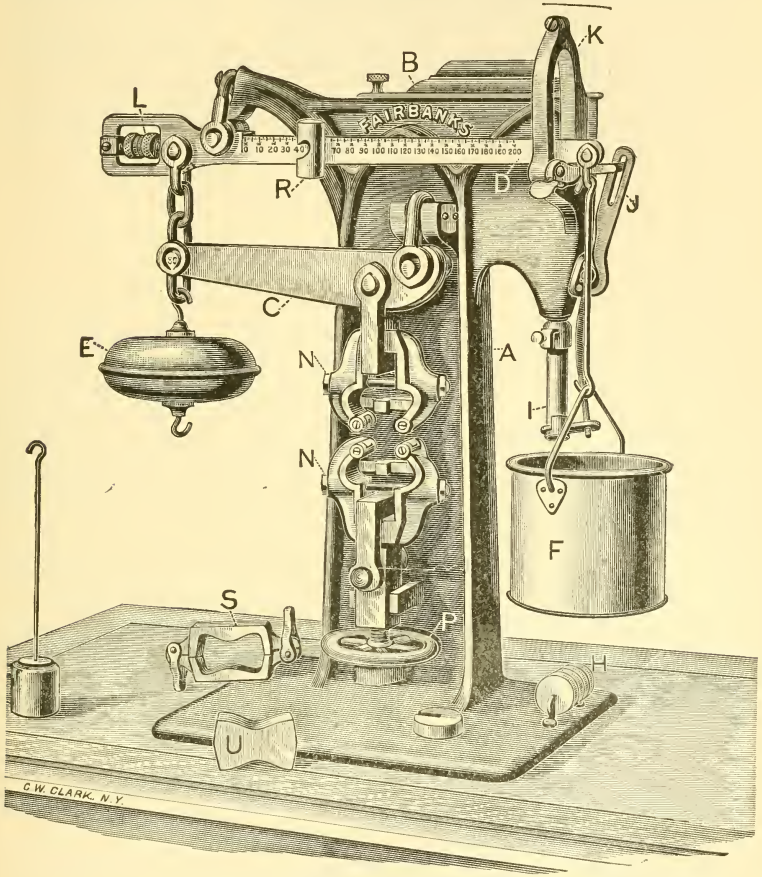
TRANSITS, LEVELS, COMPASSES, PLANE TABLES, CURRENT METERS.



LEVELING RODS, CHAINS, TAPE LINES, ANEMOMETERS, BAROMETERS, ODOMETERS.

LATEST CATALOGUE MAILED ON APPLICATION.

FAIRBANKS'
PATENT AUTOMATIC
CEMENT TESTING MACHINES.



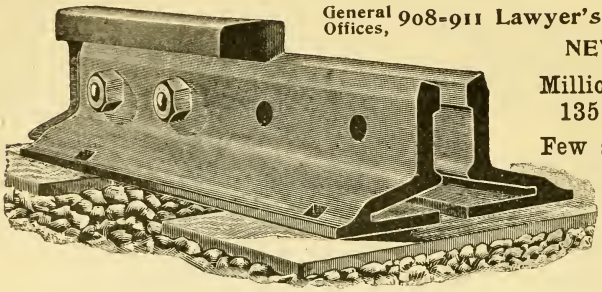
Descriptive Circular of Machines and Appliances, with Prices, Forwarded on Application.

The Fairbanks Company,

311 BROADWAY, NEW YORK.

ALBANY, N. Y.; BALTIMORE, Md.; BUFFALO, N. Y.;
BOSTON, Mass.; PHILADELPHIA, Pa.; PITTSBURG, Pa.; NEW ORLEANS, La.;
MONTREAL, Que.; LONDON, England.

CONTINUOUS RAIL JOINT CO. of AM.



General Offices, 908-911 Lawyer's Building, NEWARK, N. J.

Millions in use on 135 Railroads.

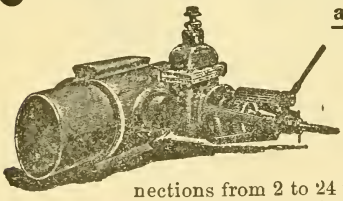
Few st parts possible. Provides for the increased tonnage up to date.

BEST ECONOMICAL RESULTS.

GIANT PORTLAND,
EGYPT PORTLAND,
IMPROVED UNION,
AND UNION CEMENTS.

MANUFACTURED BY
AMERICAN CEMENT CO., Egypt, Pa.,
LESLEY & TRINKLE, Sales Agents,
22 & 24 South 15th St., Philadelphia.

Connecting Branch Sleeve and Tapping Apparatus



For making Large Connections without Shutting Off Water or Reducing Pressure.

This is no experiment, but has been used by the Water Departments of numerous cities for years with entire success. Connections from 2 to 24 ins. have been made with mains from 4 to 48 ins. For full information, address

THE A. P. SMITH MFG. CO., 921 Prudential Building, Newark, N. J.

The Evening Post Job Printing House,

FULTON STREET, CORNER BROADWAY,

NEW YORK.

PRINTERS OF PERIODICALS.

ALCATRAZ ASPHALT

Guaranteed free from Coal Tar or Petroleum Residuum,

For Reservoir Linings and Pipe Coatings.

The Alcatraz Co.

General Offices: Bryson Block, Los Angeles, Cal., and Crocker Building, San Francisco, Cal.

ATLANTIC, GULF AND PACIFIC CO.

Hydraulic Dredge discharging through 5,700 ft. of pipe.

ENGINEERS AND CONTRACTORS

Geo. W. CATT, M Am. Soc. C. E., M. Inst. C. E., Pres. & Eng. THOS. J. LONG, M. Am. Soc. C. E., Vice Pres. & Engr.
H. S. WOOD, C. E., Sec. & Treas. H. KRUSI, C.E., Pac. Coast Man. R. A. PERRY, Supt

SPECIALTIES: Dredging, Dredging Machines, Land Reclamation, Docks, Piers, Foundations, Bridges.
Correspondence solicited.

MAIN OFFICE: PARK ROW BUILDING, NEW YORK.
PACIFIC COAST OFFICE: 220 MARKET STREET, SAN FRANCISCO, CAL.

WEST PASCAGOULA CREOSOTE WORKS,

WEST PASCAGOULA, MISS.

Situated on Pascagoula Bay and on the line of the Louisville and Nashville Railroad.

These works have been in operation for more than twenty years, were recently entirely rebuilt and enlarged, and are now prepared to execute all orders for creosoted piles and timber thoroughly impregnated with dead oil of coal tar.

New cylinders 115 feet long. Capacity, one million feet per month.

Address S. W. LABROT,
SUPT. WEST PASCAGOULA CREOSOTE WORKS,
West Pascagoula, Miss.

15,000,000 BARRELS

"HOFFMAN" CEMENT

Have been used on important works throughout the United States.

NO OTHER CEMENT COMPANY CAN SHOW SUCH A RECORD.

"DRAGON" PORTLAND

Specified by Architects and Engineers since 1889 on National, Municipal and Railroad Improvements.

Sales Office, No. 1 Broadway, New York.

Philadelphia Office, Harrison Building, 15th and Market Sts.

THE LAWRENCE CEMENT COMPANY.

E. R. ACKERMAN, PRES.

ASSOC. AM. SOC. C. E.

LABORATORIES OF Dr. CHAS. F. McKENNA, 221 PEARL ST., NEW YORK,

Successor to Dr. GIDEON E. MOORE.

DEPARTMENT OF CHEMISTRY. Analyses and Assays of Ores, Metals, Waters and Natural and Industrial Products of every description.

DEPARTMENT OF PHYSICAL TESTS. Tensile, Transverse and Compression Tests of Iron, Steel and other Metals and Alloys, Cements, Building Stones and Engineering Materials generally.

ESTABLISHED 1856.

Warren Foundry and Machine Co.

WORKS AT PHILLIPSBURG, NEW JERSEY.

SALES OFFICE: 160 BROADWAY, NEW YORK.

CAST-IRON, WATER AND GAS PIPE,

FROM 3 TO 48 INCHES DIAMETER.

Also all sizes of FLANGED PIPE and SPECIAL CASTINGS.

THE F. O. NORTON COMPANY,

—MANUFACTURER OF—

Hydraulic Cement,

92 BROADWAY, NEW YORK.

Particularly adapted for work under water, for which use it is superior to the best Portland Cement, when used 1 to 1.

Certificates of tests and reports on actual use in important public works furnished on application.

OUR LEADING

Architects, Engineers and Builders

SPECIFY AND USE

BROOKLYN BRIDGE BRAND

ROSENDALE HYDRAULIC CEMENT.

USED EXCLUSIVELY ON { PARK ROW OFFICE BUILDING—30 STORIES. WALDORF-ASTORIA HOTEL—LARGEST IN THE WORLD.

HAVE SUPPLIED FOR NEW YORK CROTON AQUEDUCT, IN 1897 AND 1898, 165,000 BARRELS.

ATLAS Portland Cement

IS THE STANDARD AMERICAN PORTLAND.

The U. S. Government gives it preference over all other brands.

ATLAS PORTLAND CEMENT CO.,

143 LIBERTY STREET, NEW YORK CITY.

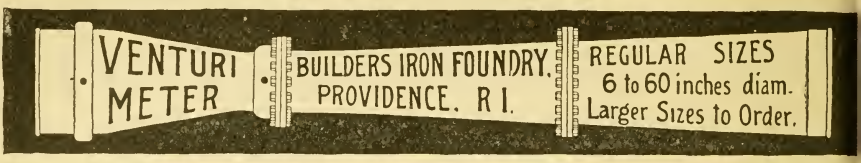
IRONCLAD PORTLAND CEMENT

Manufactured by GLENS FALLS PORTLAND CEMENT CO.

Sole Selling Agent, **Commercial Wood & Cement Co.,**

156 FIFTH AVENUE, NEW YORK.

High-grade American PORTLAND CEMENT unsurpassed for making Fine Artificial Stone.



THE VENTURI METER is the only practical meter for measuring large quantities of water.

ITS ACCURACY is unquestioned and it is frequently employed to test the accuracy of pumps.

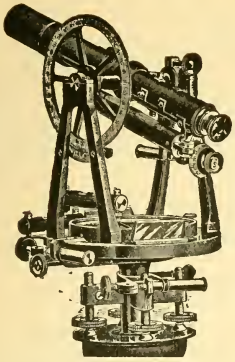
NO BY-PASS is necessary, and the cost of tees, elbows and gate-valve is avoided.

Otis Elevator Company.

HYDRAULIC, ELECTRIC AND STEAM ELEVATORS

For Passengers and Freight.

NEW YORK, BOSTON,
CHICAGO, PITTSBURG,
PHILADELPHIA, SAN FRANCISCO.



ESTABLISHED 1872.

F. E. BRANDIS SONS & CO.,

MANUFACTURERS OF

Engineers' and Surveyors' Instruments,

814 GATES AVENUE,

BROOKLYN, NEW YORK.

Catalogues mailed on application.

THE RAND DRILL COMPANY,

Pioneers in Rock Drilling and Air Compressing Machinery,

128 BROADWAY, NEW YORK,

HAS BEEN AWARDED

THREE GOLD MEDALS

AT THE

PARIS EXPOSITION

For AIR COMPRESSORS and ROCK DRILLS.

Eppinger & Russell Co.,

CREOSOTING WORKS,

Dead Oil of Coal Tar Process.

Piles and Timber treated with the above Oil for all purposes, when preservation is desired.

Introduced in England by Mr. Bethel in 1838. **DEAD OIL OF COAL TAR** is the only known product of commercial application that will preserve **TIMBER FROM DECAY, LAND AND MARINE INSECTS.**

Our Mr. Valentine has had practical experience since 1872, and we have specimens of Piles and Timber treated by him in 1874, which are in use to-day and are in a perfect state of preservation. **We have the largest and best equipped plant in the world. Cylinders 100 ft. long, capacity 1,500,000 ft. per month.**

Direct Water and Rail Communications.

MANUFACTURERS OF THE

Valentine Electrical Subway Conduit.

WORKS:	OFFICES:
Foot First Street and Newtown Creek,	MORRIS BUILDING
LONG ISLAND CITY.	66 BROAD ST., NEW YORK.

SEND FOR CIRCULARS AND PRICES.

The Brown Hoisting Machinery Company,

INCORPORATED,

MAIN OFFICE and WORKS, Cleveland, Ohio, U. S. A.

CRANES of all Types: Steam, Electric and Hand Power.

COAL AND ORE HANDLING MACHINERY.
SHIPBUILDING AND GANTRY CRANES.

Sole Builders of "BROWNHOIST" Patent High-Speed Cantilever and Gantry Cranes, for Shipyards, Works, Etc.

Eastern Office, 26 Cortlandt St., New York, N. Y.

Pittsburg Office, Carnegie Building, Pittsburg, Pa.

European Office, 39 Victoria St., London, S. W.

EXTENT OF ASPHALT PAVEMENTS

IN THE UNITED STATES AND CANADA.

Trinidad Lake Asphalt Pavement, 21,527,415 square yards, or 90%

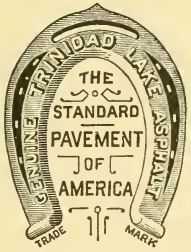
Other kinds Asphalt Pavement, 2,307,064 square yards, or 10%

OF THE TRINIDAD LAKE ASPHALT PAVEMENT

10,000,000 square yards, or nearly 50%,

WAS LAID BY

THE BARBER ASPHALT PAVING COMPANY.



This is equal to about 650 miles of Roadway, 26 feet wide.

The Asphalt used by this Company is from the famous Pitch Lake in the Island of Trinidad, B. W. I.

Plans and Estimates Furnished on Application.

GENERAL OFFICES:

LE DROIT BUILDING, - - - WASHINGTON, D. C.

BOWLING GREEN BUILDING, No. 11 Broadway, New York.

F. V. GREENE, President.

SUPERIOR GRAPHITE PAINT

For BRIDGES, ROOFS, . STRUCTURAL IRON, ...

And all Exposed Metal or Wood Surfaces.

Warranted not affected by heat, cold, salt brine, acid fumes, smoke or chemicals. . . . . .

Detroit Graphite Mfg. Co.,
DETROIT, MICH.

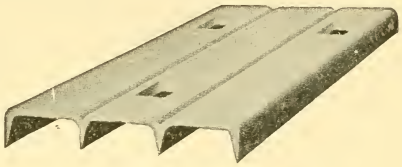
THE

Q & W Tie Plate

ALTHOUGH SOMETHING NEW,

Has a Record, from the fact that it is a combination of the

SERVIS AND WOLHAUPTER PLATES.....



THE Q AND C

CHICAGO:
700-712 Western Union Building.
NEW YORK:
106 Liberty Street.
SAN FRANCISCO:
537 Mission Street.

PROCEEDINGS

OF THE

AMERICAN SOCIETY OF CIVIL ENGINEERS.

SELECT ADVERTISEMENTS WILL BE RECEIVED AT THE FOLLOWING RATES:

	ONE YEAR. 10 INSERTIONS.	½ YEAR. 5 INSERTIONS.	3 INSERTIONS.
One Page.....	$170 00	$95 00	$60 00
One-half Page.....	90 00	55 00	35 00
One-quarter Page	50 00	30 00	20 00
One-twelfth Page, Card	20 00	.....	.....

Address the Secretary of the Society, 220 West 57th Street, New York.

THE

AMERICAN BRIDGE COMPANY

DESIGNERS AND
BUILDERS OF . .

Steel Bridges, Steel Buildings

AND ALL CLASSES OF

Metallic Structures.

OFFICES:

100 BROADWAY, NEW YORK.

AMERICAN SOCIETY

OF

CIVIL ENGINEERS

PUBLIC LIBRARY
BROOKLINE

February, 1901

PROCEEDINGS = VOL. XXVII—No. 2

Published at the House of the Society, 220 West Fifty-seventh Street, New York, the Fourth Wednesday of each Month, except June and July.

Copyrighted, 1901, by the American Society of Civil Engineers.
Entered as Second-Class Matter at the New York City Post Office, December 15th, 1896.

Vol. XXVII. FEBRUARY, 1901. No. 2.

PROCEEDINGS

OF THE

AMERICAN SOCIETY OF CIVIL ENGINEERS.

Edited by the Secretary, under the direction of the Committee on Publications.

CONTENTS.

SOCIETY AFFAIRS.

	PAGE.
Minutes of Meetings:	
Of the Annual Meeting, January 16th, 1901	25
Of the Society, February 6th and 20th, 1901	27
Of the Board of Direction, January 16th and February 5th, 1901	29
Report in Full of the Annual Meeting, January 16th and 17th, 1901	31
Announcements:	
Hours during which the Society House is open	65
Meetings	65
Annual Convention	65
Additions to Library	66
Recent Engineering Articles of Interest	67
New Books of the Month	74
Donations to the Library	78
Membership (Additions)	79

PAPERS AND DISCUSSIONS.

Paper to be presented:

Heavy Railway Construction in Wyoming.
By J. I. Boggs, Assoc. M. Am. Soc. C. E. 44

Discussions on Papers which have been presented:

Canals between the Lakes and New York.
By Messrs. Rudolph Hering, R. P. J. Tutein-Nolthenius, George W. Rafter, Joseph Mayer and George Y. Wisner 60

The Kinzua Viaduct of the Erie Railroad Company.
By Messrs. H. A. LaChicotte, G. Lindenthal and F. H. Cilley 91

A Direct Method of Spacing Rivets and Finding the Position, Etc., of Stiffeners in Plate Girders.
By Messrs. H. A. LaChicotte, O. F. Nichols, F. D. Rhodes, Ernst F. Jonson and E. Schmitt 106

The Adjustment of a Transit Survey as compared with that of a Compass Survey.
By George W. Tuttle, Esq. 119

PLATES.

Plate I.	Heavy Railway Construction, U. P. Ry., Wyoming	49
Plate II.	Portal of Sherman Tunnel, U. P. Ry., Wyoming	51
Plate III.	East Approach Sherman Tunnel, U. P. Ry., Wyoming	53
Plate IV.	"Gibraltar," U. P. Ry., Wyoming; and Engineer's House	55

The prices of publications are as follows: *Proceedings*, $6 per annum; *Transactions*, $10 per annum. Postage will be added when *Proceedings* are sent to foreign countries.

American Society of Civil Engineers.

OFFICERS FOR 1901.

President, J. JAMES R. CROES.

Vice-Presidents.

Term expires January, 1902:
RUDOLPH HERING,
ALFRED NOBLE,

Term expires January, 1903:
HENRY S. HAINES,
GEORGE H. BENZENBERG.

Secretary, CHARLES WARREN HUNT.

Treasurer, JOSEPH M. KNAP.

Directors.

Term expires January, 1902:	*Term expires January, 1903:*	*Term expires January, 1904:*
JOHN A. BENSEL,	JOHN F. O'ROURKE,	JOSIAH A. BRIGGS,
C. W. BUCHHOLZ,	HENRY B. SEAMAN,	GEORGE F. SWAIN.
SAMUEL WHINERY,	THOMAS H. JOHNSON,	EMIL KUICHLING,
EDMUND K. TURNER,	JOSEPH RAMSEY, JR.,	MORDECAI T. ENDICOTT
PALMER C. RICKETTS,	HENRY B. RICHARDSON,	EDWARD C. CARTER,
JAMES D. SCHUYLER.	GEORGE A. QUINLAN.	FRANK C. OSBORN.

Assistant Secretary, T. J. McMINN.

Standing Committees.

THE PRESIDENT OF THE SOCIETY IS *ex-officio* MEMBER OF ALL COMMITTEES.

On Finance:	*On Publications:*	*On Library:*
SAMUEL WHINERY,	RUDOLPH HERING,	JOHN A. BENSEL,
C. W. BUCHHOLZ,	PALMER C. RICKETTS,	H. S. HAINES,
JOSIAH A. BRIGGS,	JOHN F. O'ROURKE,	M. T. ENDICOTT,
G. H. BENZENBERG,	JAMES D. SCHUYLER,	E. KUICHLING,
GEORGE F. SWAIN.	ALFRED NOBLE.	CHARLES WARREN HUNT.

Special Committees.

ON ANALYSIS OF IRON AND STEEL:—Sub-Committee of the American Society of Civil Engineers (of the International Committee on Standards for the Analysis of Iron and Steel, of which Prof. J. W. Langley is Chairman)—Charles B. Dudley, William Metcalf, Thomas Rodd.

ON UNITS OF MEASUREMENT:—George M. Bond, William M. Black, R. E. McMath, Charles B. Dudley, Alexander C. Humphreys.

ON THE PROPER MANIPULATION OF TESTS OF CEMENT:—George F. Swain, Alfred Noble, George S. Webster, W. B. W. Howe, Louis C. Sabin, H. W. York.

The House of the Society is open every day, except Sunday, from 9 A.M. to 10 P.M.

HOUSE OF THE SOCIETY—220 WEST FIFTY-SEVENTH STREET, NEW YORK.

TELEPHONE NUMBER, - - - 533 Columbus.
CABLE ADDRESS, - - - - "Ceas, New York."

Vol. XXVII. FEBRUARY, 1901. No. 2.

AMERICAN SOCIETY OF CIVIL ENGINEERS.

INSTITUTED 1852.

PROCEEDINGS.

NOTE.—This Society is not responsible, as a body, for the facts and opinions advanced in any of its publications.

SOCIETY AFFAIRS.

CONTENTS:

	PAGE
Minutes of Meetings:	
Of the Annual Meeting, January 16th, 1901	25
Of the Society, February 6th and 20th, 1901	27
Of the Board of Direction, January 16th and February 5th, 1901	29
Report in Full of the Annual Meeting, January 16th and 17th, 1901	31
Announcements:	
Hours during which the Society House is open	65
Meetings	65
Annual Convention	65
Additions to Library	66
Recent Engineering Articles of Interest	67
New Books of the Month	74
Donations to the Library	78
Membership (Additions)	79

MINUTES OF MEETINGS.

OF THE SOCIETY.

FORTY-EIGHTH ANNUAL MEETING.*

January 16th, 1901.—The meeting was called to order at 10.20 A. M. President John F. Wallace in the chair; Charles Warren Hunt, Secretary; and present, also, 255 members and 20 guests.

Messrs. William B. Fuller, Oscar Erlandsen and Oscar Lowinson were appointed tellers to canvass the Ballots for Officers for the ensuing year.

On motion, the reading of the minutes of the meeting of January 2d, 1901, was dispensed with.

The Annual Report† of the Board of Direction for the year ending

* A full report of the Forty-eighth Annual Meeting is printed on pages 31 to 64 of this number of *Proceedings*.

† See pages 5 to 14, January, 1901, *Proceedings*, for the Annual Reports of the Board of Direction, the Secretary and the Treasurer.

December 31st, 1900, and the Annual Reports of the Treasurer and of the Secretary were presented, and, on motion, duly seconded, accepted.

The Secretary reported that, in accordance with the recommendations of the Committee on Prizes, the Board of Direction has awarded the prizes for the year ending with July, 1900, as follows:

The Norman Medal to James A. Seddon, M. Am. Soc. C. E., for Paper No. 871, entitled "River Hydraulics."

The Thomas Fitch Rowland Prize to Allen Hazen, M. Am. Soc. C. E., for Paper No. 872, entitled "The Albany Water Filtration Plant."

The Collingwood Prize for Juniors to Robert P. Woods, Jun. Am. Soc. C. E. (now Assoc. M. Am. Soc. C. E.), for Paper No. 853, entitled "Street Grades and Cross-Sections in Asphalt and Cement."

The consideration of the following proposed amendment to the Constitution was then taken up:

"Amend Section 5 of Article II by adding the following:

"*The Board of Direction may transfer any Junior elected prior to March 4th, 1891, to the grade of Associate.*"

This amendment was proposed by Messrs. George S. Morison, S. Whinery, Joseph M. Knap, John Bogart and C. C. Schneider.

The amendment was not amended.

The following were appointed members of the Nominating Committee for two years:

Ira A. Shaler.	*Representing District No.*			*1.*
S. E. Tinkham.	"	"	"	*2.*
John F. Alden.	"	"	"	*3.*
Paul L. Wolfel.	"	"	"	*4.*
Onward Bates.	"	"	"	*5.*
R. Montfort.	"	"	"	*6.*
Charles D. Marx.	"	"	"	*7.*

The Secretary read a letter from T. Kennard Thomson, M. Am. Soc. C. E., inviting members to inspect the work on the pneumatic foundations for the Mutual Life Building.

George F. Swain, M. Am. Soc. C. E., Chairman of the Committee on the Proper Manipulation of Tests of Cement, presented a progress report, and suggested that as the Committee had lost one of its members by resignation, it might be well to increase the number of members on that Committee.

On motion, duly seconded, the Committee was empowered to increase its number if it so desires.

The Secretary announced additional details of the programme of the various excursions, etc.

The Secretary presented the report* of the tellers appointed to canvass the Ballot for Officers for the ensuing year.

*This report is printed on page 58 of *Proceedings*. The minutes of the meeting in full are printed on pages 31 to 64, *Proceedings*.

The President announced the election of the following officers:

President, to serve one year:

J. James R. Croes, New York City.

Vice-Presidents, to serve two years:

Henry S. Haines, New York City.
George H. Benzenberg, Milwaukee, Wis.

Treasurer, to serve one year:

Joseph M. Knap, New York City.

Directors, to serve three years:

District No. 1.—Josiah A. Briggs, New York City.
District No. 2.—George F. Swain, Boston, Mass.
District No. 3.—Emil Kuichling, Rochester, N. Y.
District No. 4.—Mordecai T. Endicott, Washington, D. C.
District No. 5.—Edward C. Carter, Chicago, Ill.
District No. 5.—Frank C. Osborn, Cleveland, Ohio.

Mr. Croes, President for 1901, was introduced by Mr. Wallace, and took the chair.

Adjourned.

February 6th, 1901.—The meeting was called to order at 8.50 P. M. President J. James R. Croes in the chair; Charles Warren Hunt, Secretary; and present, also, 60 members and 7 guests.

The minutes of the meeting of January 2d, and of the Annual Meeting on January 16th, 1901, were read by the Secretary, and approved.

A paper by Charles L. Crandall, M. Am. Soc. C. E., entitled, "The Adjustment of a Transit Survey as Compared with that of a Compass Survey," was presented by the Secretary, who also read a communication on the subject from Mr. George W. Tuttle.

The paper was discussed orally by Messrs. J. H. Fuertes, W. H. Luster, Jr., and W. B. Lee.

Ballots were canvassed, and the following candidates were declared elected:

As Members.

Julius Baier, Virginia City, Mont.
Benjamin Wilder Guppy, Portland, Me.
Benjamin Mortimer Hall, Atlanta, Ga.
Eugene Klapp, New York City.
Ambrose Vincent Powell, Chicago, Ill.
David Alexander Watt, Bowling Green, Ky.
Cyrus John Richard Williams, Brisbane, Queensland.

As Associate Members.

William Andrew Allen, Perth Amboy, N. J.
William Israel Bishop, Montreal, Que.
Edwin Stanton Fickes, Pittsburg, Pa.
Edward McKim Hagar, Chicago, Ill.
Allen Crosby Hardison, Santo Domingo Mines, Peru.
George Prince Hawley, Shawenegan Falls, Que.
Wallace Chittendon Lyon, Washington, D. C.
Samuel Dickerson Rockenbach, Santiago, Cuba.
George Albert Soper, New York City.

The Secretary announced that the following candidates were elected by the Board of Direction on February 5th, 1901:

As Associate.

George Oliver Tenney, Spartanburg, S. C.

As Juniors.

George Washington Corrigan, Evanston, Wyo.
George Gere MacCracken, New York City.
Charles Herbert Nutter, New York City.
Francis Repetti Weller, Washington, D. C.

The Secretary announced that at the meeting of the Board of Direction, February 5th, 1901, the ballot on the reconsideration of James Hollis Wells was canvassed, and that Mr. Wells was declared elected as a member.

The Secretary announced the acceptance of the following resignations:

William Johnston Sproule, elected Member, September 1st, 1886.
John Jay Lafayette Houston, elected Associate Member, May 4th, 1892.
Walter Grant Penfield, elected Junior, March 3d, 1896.

Adjourned.

February 20th, 1901.—The meeting was called to order at 8.35 P.M.; President J. James R. Croes in the chair; Charles Warren Hunt, Secretary; and present, also, 72 members and 13 guests.

A paper, entitled "The Construction of Gravity Sand Filters at Nyack, N. Y.," by G. N. Houston, Assoc. M. Am. Soc. C. E., was presented by the Secretary, who also read a communication on the subject from James S. Haring, M. Am. Soc. C. E.

A written discussion of the paper by James H. Fuertes, M. Am.

Soc. C. E., was presented by F. S. Skinner, M. Am. Soc. C. E., and the subject was discussed further by Messrs. L. L. Buck, Gustave Kauffman, James Owen, M. Knowles and R. A. MacGregor.

The Secretary announced the following deaths:

Levis Passmore Pennypacker; elected Associate Member April 1st, 1891; died January 30th, 1901. George Washington Howell; elected Member May 2d, 1888; died February 15th, 1901.

Adjourned.

OF THE BOARD OF DIRECTION.

(Abstract.)

January 16th, 1901.—3 P. M.—President Croes in the chair; Chas. Warren Hunt, Secretary; and present, also, Messrs. Briggs, Hering, Knap, O'Rourke, Osborn, Ricketts, Seaman, Swain, Turner, Wallace and Whinery.

The President was authorized to appoint and announce later the Standing Committees.

On the recommendation of the Finance Committee, the payment of five thousand dollars ($5 000) on the principal of the mortgage debt was authorized.

A letter-ballot was ordered for the election of a Secretary for the ensuing year.

Adjourned to meet February 5th, 1901.

February 5th, 1901.—8.40 P. M.—President Croes in the chair; Chas. Warren Hunt, Secretary; and present, also, Messrs. Briggs, Hering, Knap, Noble, O'Rourke, Ricketts, Seaman, Swain, Turner and Whinery.

The appointment of the following Standing Committees was reported:

Finance Committee: S. Whinery, *Chairman;* C. W. Buchholz, Josiah A. Briggs, George H. Benzenberg, George F. Swain.

Publication Committee: Rudolph Hering, *Chairman;* Palmer C. Ricketts, John F. O'Rourke, James D. Schuyler, Alfred Noble.

Library Committee: John A. Bensel, *Chairman;* Henry S. Haines, Emil Kuichling, Mordecai T. Endicott, Charles Warren Hunt.

Ballots in the matter of the election of a Secretary were canvassed, with the following result: That twenty-six ballots in all were received, all in favor of Charles Warren Hunt for Secretary.

The President declared Charles Warren Hunt elected Secretary of the Society.

The matter of members in arrears for dues was considered and action taken.

The matter of the presentation of papers by abstract and the securing of such abstracts from authors was considered, and authority given to the Committee on Publications to take action in regard to abstracts of papers as it may deem advisable.

Ballots on the reconsideration of the vote by which James Hollis Wells was rejected were canvassed, and Mr. Wells was elected a Member of the Society.

Resignations were received and accepted from one Member, one Associate Member and one Junior.

It was decided that hereafter the Library of the Society shall not be opened on July 4th, Thanksgiving Day, and Christmas Day.

Applications were considered and other routine business transacted.

One candidate for Associate and four for Junior were elected.

Adjourned.

REPORT IN FULL OF THE FORTY-EIGHTH ANNUAL MEETING, JANUARY 16th and 17th, 1901.

Wednesday, January 16th, 1901.—The meeting was called to order at 10.20 A. M.; John F. Wallace, President, in the chair; Charles Warren Hunt, Secretary. Meeting called to order.

The PRESIDENT.—Gentlemen, will you please come forward and take front seats? The first thing in order is the reading of the minutes of the meeting of January 2d, 1901. The minutes of that meeting, in accordance with custom, will be printed in the January *Proceedings*, and will come up in due course for action at the meeting of February 6th, 1901. In view of this fact, the reading of those minutes will be dispensed with, provided there is no objection. Minutes of Last Meeting.

Next in order is the appointment of Tellers to canvass the vote for officers for the ensuing year. I will appoint Mr. William B. Fuller, Mr. Oscar Erlandsen and Mr. Oscar Lowinson. These gentlemen will find the ballots in the other room, and the clerical force will assist them in the count, which will go on at once, although the ballot does not close until twelve o'clock, noon. Tellers Appointed.

Any ballots that come in between now and twelve o'clock will be counted before the final result is announced.

The next thing in order is the report of the Board of Direction. The Secretary will read it.

The Secretary read the report of the Board of Direction.*

The PRESIDENT.—I would like to ask the indulgence of the Society to make a few remarks in relation to this report before asking you what you shall do with it. One thing that has struck me most forcibly during the last year is in regard to admissions into the Society, and the elements that enter into the question of the rejection of applicants. We should, of course, guard the portal to our organization with the utmost care, and see that none but those who are worthy should enter. On the other hand, we should avoid any action as an organization, or as individual members of the Society, which unnecessarily keeps out men who are worthy. The Membership Committee and the Board of Direction give a most careful scrutiny to every applicant whose name appears on the Blue List before the ballot is sent out. It is the duty of every member to inform the Board if there is any reason why any candidate is not worthy of membership. The character of the negative votes that come in is at times very peculiar. A great many times men are voted against by quite a number of members, and when the notice of a proposed reconsideration of the ballot is sent out, these men do not come forward and state their reasons for so voting. Would you ask any stronger proof that in those Report of the Board of Direction.

* See *Proceedings*, Vol. xxvii, p. 5 (January, 1901).

Discussion on Report of the Board of Direction.

cases the negative votes have been made on personal grounds, personal prejudice, or have been ill-considered? In the West, among a great many engineers with whom I am acquainted, some of them men that have had years of experience, are fully qualified, and would make desirable members, I have frequently, in calling their attention to the fact that they should connect themselves with our Society, been met with the response that their record was long and that they did not propose to subject themselves to the chance of being black-balled by men who had worked for them and had left their service; men from whom they had differed radically in opinion, and men from whom they might expect action of that sort. We should never permit our Society to take such action as would make it hard for an engineer with a record, and who is thoroughly qualified, to be admitted. Among the peculiar features of some of the ballots that we have lately received, I will mention one in particular. There was quite a number of names on the ballot, and the record of each of the first five or six names on that list occupied about 1½ or 2 ins. of space. At the foot of the list was a man whose record occupied 5 or 6 ins. One member voted no against every one of the applicants with the short records, and in favor of the one with the long record. It looked very much as if this individual member had sized up the records of the applicants by the inch. And this is not an isolated case; it is simply a sample of the way a great many of our members act in relation to this question of balloting. Now such things are beneath the dignity of our profession and beneath the dignity of this Society. I have not spoken to you too strongly on this subject; but it has been one of the things that has attracted my attention in the meetings of the Board of Direction more than any one thing.

What action will the Society take on this report?

E. Sherman Gould, M. Am. Soc. C. E.—Mr. Chairman, if it is in order to make any remarks in the line which you have indicated, I would say——

The President.—The first thing in order would be a motion to accept the report.

Mr. Gould.—I beg your pardon.

Robert Cartwright, Vice-President, Am. Soc. C. E.—I move that the report be accepted. (Seconded.)

The President.—It is moved and seconded that the report be accepted. Any remarks? Now we will hear you.

Mr. Gould.—I heartily agree with the view which our President has announced, and I think with him that every one who casts a negative vote should be prepared to state distinctly over his signature what his reasons are. I have myself cast two negative ballots since I have been a member of the Society; one a negative ballot after an inspection of the Blue List, and one a negative ballot on a reconsideration ballot.

They were both cast for the simple reason that the printed record in the Blue List did not come up to the constitutional requirements of membership. Counting up the dates, the time was not fulfilled; and counting up the record, that was not fulfilled. Those were the only two reasons, and I can imagine no other reason why a negative ballot should be cast against a proposed member except those reasons, and personal reasons—that is to say, something against the personal character of the applicant as an engineer and a gentleman. I have been surprised to see, as I dare say a number of our members have been, the great number of reconsideration ballots, and in view of the fact that the constitutional requirements for membership are so explicit and so capable of practical application, I cannot imagine why such a large number of reconsideration ballots come up, why so many negative votes are cast; except it be, as the Chairman has said, for personal reasons or from the fact which influenced my own decision. Either I have entirely misinterpreted the plain language of the Constitution, or we have repeatedly had applicants received and admitted to the Society whose records did not fulfill the constitutional requirements of membership in the class to which they were elected.

The PRESIDENT.—Gentlemen, in addressing the Chair, will please follow our usual custom of giving their names when they rise.

FOSTER CROWELL, M. Am. Soc. C. E.—Mr. President, this is a matter that goes very much further than the effect on a candidate, no matter how mischievous that effect on a candidate may be. It affects the stability, the importance of the Society in coming years. The Society is now so large that the present method of electing by ballot is no longer useful. It used to be, when the membership was smaller and when the candidates who came up were more generally known to the membership than is the case at present. It seems to me that there is only one remedy for this condition which the President has described, and that is a constitutional amendment putting the election of candidates in the hands of the Board after the same opportunities for acquiring information in regard to them as now prevails have been given to the members of the Society.

SAMUEL WHINERY, Director, Am. Soc. C. E.—As our President has indicated, the Board of Direction of the Society has given this question a good deal of consideration. I may say that it went so far as to appoint a committee to consider the whole subject and to report to the Board. As has been said, it is not a very easy question to deal with. I believe that upon a very careful consideration of all the conditions, most members will come to the conclusion that it is desirable to retain, at least, under the present constitutional form of electing members, that clause which allows a small number of negative votes to reject. It is perfectly conceivable that there may be instances—in fact I know of one myself in the history of the Society, where a man

Discussion on Report of Board of Direction (continued).

who had been guilty of unworthy acts, known only to a subordinate, was an applicant for membership in this Society. That subordinate was a member. His bread and butter depended upon his position. He could not very well publicly—he could not take the risk, even in a confidential letter to the Board of Direction—to point out why his superior was unfit to be a member of the Society. There was only one thing left for him to do under those circumstances, and that was to take advantage of the clause in the Constitution which allows a small number of negative votes to reject. Now there may be other similar circumstances. I believe that until at least such a sweeping change in the Constitution as Mr. Crowell points out shall be made, it is desirable to retain this provision of the Constitution allowing a small number of votes to reject. But at the same time, as our President has pointed out—and I do not wish to go over the same ground—there are not many engineers who have attained some degree of eminence in the profession, who have had a large amount of experience, who are men of positive character, such men as we wish to become members of the Society, who have not been so unfortunate at some time in their professional life as to make some enemies; and, unfortunately, those enemies are not always guided by the highest sense of honor when it comes to balloting for the admission of members. I think if members before casting a negative ballot would consider the subject very thoroughly, that on the basis, not only of personal honor, but of professional honor, they would never allow merely personal motives, of hatred or professional difference, to govern their action in casting ballots for membership, and I think that that is the point which it is desirable to insist on—that no man who is worthy to be a member of the American Society of Civil Engineers, who is a gentleman and an honorable member of the profession, can cast a ballot against another honorable member of the profession simply for personal reasons. I think that point of view has to be impressed. The method at present provided for excluding unworthy members is ample, as our President has pointed out, and the Board, as he has also said, has been exceedingly careful not to admit members against whom there is any valid charge or any valid ground for rejecting. It may be interesting to the Society at large to know that in some cases an application for membership has been held up for more than a year because of a comparatively trivial charge by one member of the Society, until that charge could be very thoroughly investigated and either substantiated or disproved. I think, as the Board stands now—if you will pardon me for saying so—and as it has been for many years, members of the Society are perfectly safe in confiding any reasons of that character they may have to the Board, and I think they are further perfectly safe in counting that the Board will deal in the most careful manner, will give the fullest consideration to any communication of that kind, and I think if the matter is pres-

ented in that way members will find very few unworthy people are admitted to the Society. Of course, the Board of Direction does not know, perhaps, one out of a hundred of these applicants. They must depend upon the information they obtain from the membership at large in order to act intelligently upon the applications.

Mr. Cartwright.—Only to reinforce the remarks of our President and our friend Whinery—if the members of the Society knew the care that is taken by the Board of Direction in the examination of candidates, they would feel well satisfied that the subject might be left to the Board. I never have cast a negative ballot. If a man proves by his record, so far as published, to be qualified and also is endorsed by worthy members of the Society, I vote for him. But, as the President justly says, this pink ballot business comes back pretty often now. The only thing I could suggest is that, when these negative votes come in, the Board of Direction demand of those casting the negative votes to know the reason why. Face the music. Come out and say what you have got to say. That is one remedy that the Board of Direction can enforce. As the President has justly said, when it comes to the pink ballot, those that voted negatively on the first application do not come forward with anything, but let it go by default. The vote is a good deal like an anonymous letter, which no man but a coward will ever write. I think you may well leave it in the hands of the Board of Direction. If you had been in the Board of Direction and knew the facts, I think you would say that whoever the Board of Direction passes is worthy of our Society. This is based upon a good many years' connection with the Society. Of course, our Society has grown beyond what anybody ever dreamed it would be. At the same time, we have a safeguard in the fact that the Board of Direction can demand the reasons why you voted no.

The President.—Are there any further remarks, gentlemen, on this question?

Mendes Cohen, Past-President, Am. Soc. C. E.—Mr. President, I would like to say a word on the subject. It is a matter which I have observed for a long while, and even as long ago as when I was a member of the Board, the same difficulty would come up. It grows out of the fact, as has been said, that, with the extended membership in the Society at present, a negative vote is so entirely concealed and may be made so effective that members can satisfy their personal spite; and a good deal of this negative voting is due to that, I have no doubt. There is but one remedy for this, in my opinion. It is not in educating up the members to do the fair and honorable thing. Those that are capable of such an appeal will do the proper thing now. It can only be met by putting the election into the hands of the Board, where I have long thought it properly belonged. It may be well in an amendment to the Constitution, looking to such change in the method, to

Discussion on Report of Board of Direction (continued).

practically increase the Committee on Membership by adding representative members, selected by the Board, with the consent of the member from each and every district; and when objections are made to individuals from such district or such location, it may be well to refer to the member from that locality—the member of the Membership Committee—and the additional member of the Membership Committee in that locality can canvass on the spot, as near as may be, the reputation and standing of the candidate. With such information, the Board is in the best possible position to pass upon the merits of the candidate, and certainly far better able to give a satisfying result to the Society at large than can the secret ballot.

The PRESIDENT.—There is one very pertinent idea in connection with Mr. Cohen's remarks, and that is the bringing of the far-away and the non-resident membership into a responsible connection with the Society in reference to action on applications for memberships would very much strengthen and tie our Society together. The Institution of Civil Engineers of Great Britain, I believe, has now adopted a similar plan. I think in some of their colonies, particularly in Canada, they have advisory councils, that are made up of the non-resident members, to whom applications are referred that come from that colony or that territory. The one strength of our Society in the future must be through its non-resident membership, through a large non-resident membership. Those men must be brought into touch with our Society work. It is impossible for them to take part in the monthly meetings regularly. They, of course, receive our publications, and most of them realize the burden that is put upon the resident members to carry on the business of the Society; but they should be brought in touch, as much as possible, with the work of the Society, and this is one way in which it could be done.

Are there any further remarks?

W. B. LEE, M. Am. Soc. C. E.—Mr. President, there are two points to which I would like to call attention. The first is in regard to what Mr. Gould has just said concerning his manner of arriving at a decision as to whether he should vote for a candidate or not, and he says that he carefully considered whether the man's record was sufficient to fill the constitutional requirements. Now, I understand that is a matter that is considered by the Board of Direction before the Blue List and before the ballot is issued, and that, upon the face of it, the record, in their judgment, does come up to the constitutional requirements. That, it seems to me, would be sufficient.

With regard to another point I have been credibly informed that there is a small portion of the membership of the Society that believes that the Constitution is a little lame and that a man should be forty years of age instead of thirty in order to be a full-fledged member of

the American Society of Civil Engineers. I do not know whether that is true or not.

The PRESIDENT.—That is all right for those of us that are in. (Laughter.)

While not desiring to digress, there is another feature of the application for membership. In the Institution of Civil Engineers of Great Britain, a man is not permitted in his application to signify the class that he desires to be placed in. As I understand it, he applies for membership in the Society, and it remains with the Board of Direction to say whether he shall be a full member or an associate member, or classify him where he properly belongs. Of course the Board must exercise a great deal of discretion, particularly with reference to that qualification which is designated as "responsible charge of work." In regard to age, or in regard to length of experience, that is a matter that is very easily checked; but except by an acquaintance with a man, or by correspondence with his endorsers, it is very difficult sometimes to determine whether a man is qualified or not, and a great many times the men who are more modest than others will word their record in such a way that it will look inferior to that of a man who has a stronger imagination (laughter) or an ability to place his record in a better light.

Any further remarks? If not, all in favor of the acceptance of the report of the Board of Direction will signify by saying Aye; contrary, No.

The motion was carried.

The PRESIDENT.—It is accepted. The next in order is the report of the Treasurer. Treasurer's Report.

Mr. J. M. Knap read the report of the Treasurer.*

The PRESIDENT.—Is there a motion to accept this report?

Mr. CARTWRIGHT.—I move that the report be accepted.

(Seconded.)

The motion was carried.

The PRESIDENT.—The report of the Treasurer is accepted. Next in order is the report of the Secretary.

Mr. Charles Warren Hunt, the Secretary, read his report.† Secretary's Report.

The PRESIDENT.—Gentlemen, what do you desire to do with this report?

A MEMBER.—I move that it be received. (Seconded.)

The motion was carried.

The PRESIDENT.—The Report of the Board of Direction on the Award of the Norman Medal and the Rowland Prize is next in order.

The Secretary read the following Report:

* See *Proceedings*, Vol. xxvii, p. 14 (January, 1901).

† See *Proceedings*, Vol. xxvii, p. 10 (January, 1901).

Report of Committee on Award of Prizes.

DECEMBER 22D, 1900.

To the Board of Direction,

AMERICAN SOCIETY OF CIVIL ENGINEERS.

The Committee to recommend the award of prizes for the year ending July, 1900, respectfully reports the following recommendations:

That the Norman Medal be awarded to James A. Seddon, M. Am. Soc. C. E., for his paper entitled "River Hydraulics" (No 871).

That The Thomas Fitch Rowland Prize be awarded to Allen Hazen, M. Am. Soc. C. E., for his paper entitled "The Albany Water Filtration Plant" (No. 872).

That The Collingwood Prize for Juniors be awarded to Robert P. Woods, Assoc. M. Am. Soc C. E., for his paper entitled "Street Grades and Cross-Sections in Asphalt and Cement" (No. 853).

The Committee calls attention to the fact that this paper was written, published and discussed prior to Mr. Woods' transfer to the grade of Associate Member.

Respectfully submitted,

JOSEPH MAYER,
ARTHUR N. TALBOT,
S. E. TINKHAM.

The SECRETARY.—I have to report that the Board of Direction has awarded the prizes in accordance with the recommendations of the Committee.

The PRESIDENT.—No action is necessary on this Report. It is simply for the information of the Society.

Proposed Amendment to the Constitution.

There is a proposed amendment to the Constitution to be considered at this meeting. The Constitution states as follows:

"Such amendments shall be in order for discussion at such Annual Meeting, and may be amended in any manner pertinent to the original amendments by a majority vote of the Annual Meeting, and if so amended shall be voted upon by letter-ballot in form as amended by the Annual Meeting; if not so amended, they shall be voted upon by letter-ballot as submitted. The vote to be counted at the first regular meeting in March."

The proposed amendment reads as follows:

"Amend Section 5 of Article II by adding the following: 'The Board of Direction may transfer any Junior elected prior to March, 1891, to the grade of Associate.'"

Proposed by George S. Morison, S. Whinery, Joseph M. Knap, John Bogart and C. C. Schneider.

Before opening this for general discussion, I would like to call the attention of the Society to the last paragraph of Section 6 in relation to Junior membership. It says:

"Persons who are in the Junior class at the time of the adoption of this Constitution shall not have their status changed by the provisions of this section."

While it is true that we have the power to amend our Constitution, it is also true that that clause of that Section of Article II seems to me to be in the nature of a contract which we entered into with those

who were Junior members at the time this Constitution was adopted. Now it is a question on which I am not clear, whether, while we may technically have the power to change that clause, we have the moral right to do so. Now, of course, the members of the Society have to judge of that themselves. I simply consider it my duty to call your attention to that phase of the question. The motive, of course, of this amendment is a very proper one, and that is the desire to eliminate from our Junior membership men that have been in that class a great many years and who are perfectly qualified, or should be qualified by this time, to go into a higher class. But it is a question whether we can or should amend the Constitution so as to force them into a higher class without their own consent. It would seem, however, that with their consent it would be perfectly proper to do it. The matter is now open for general discussion.

J. M. Knap, M. Am. Soc. C. E.—Is this matter of the amendment before the house?

The President.—The matter is now before the house.

Mr. Knap.—I wish to say, Mr. Chairman and gentlemen, that I signed that amendment without feeling that I wanted it to be passed just exactly in that shape. But the gentleman who asked me to sign it said it would be brought up for consideration at this meeting and, of course, could be amended. I therefore signed it as it went out, feeling no harm would be done, and I take the occasion, sir, now to move an amendment to that amendment which I will read and which can be discussed. The amendment that I propose is this: Strike out the final sentence of Section 6 of Article II (that is the Article you referred to, sir, in your speech just now) as follows: "Persons who are in the Junior class at the time of the adoption of this Constitution shall not have their status changed by the provisions of this Section." That I propose to have stricken out and substitute therefor the following:

"Persons who became Juniors on or before the date of the adoption of this Constitution may be transferred to other classes of membership by the Board of Direction. Until so transferred, they shall continue to be Juniors."

I would simply say here that we have discussed it in the Board, and letters have been sent out to all of those we call the old Juniors on the subject of having them transferred, say, to the grade of Associate, and replies were received from many of them not objecting. Others did object. Others objected very decidedly to being transferred to that grade. Therefore, it was afterwards decided by the Board that an amendment of this kind should be sent out to be voted upon. It seems to me that these Juniors, some of them now 40 or 50 years of age, would be only too glad to be transferred to some other grade of membership, and in this way it can be done by the Board of Direction. They can vote on it understandingly, and no harm will be done, and

Discussion on Amendment to Constitution (continued).

none of the rights of Juniors are taken away, I think, by the adoption of the amendment which I propose.

The PRESIDENT.—Is there any second to Mr. Knap's amendment to the original amendment?

Mr. WHINERY.—Mr. President, in seconding the amendment proposed by Mr. Knap, I wish to say I am very sorry that the member, who is a prominent member of the Society, who originally took this matter up and investigated it and who has been the strongest advocate of it, is not here to-day, and I should like to present very briefly the arguments that he thinks are sufficient to warrant the adoption of some amendment of this character. This class is an anomalous class in the Society, and a very small class, and for that reason alone it would be desirable to eliminate that class if it could be done in a satisfactory manner. As has been stated here, some of these Juniors who were elected Juniors previous to the adoption of this Constitution are now gentlemen, not only mature in age, but prominent in their branches of the profession. Among other things in the Society we have a prize offered to Junior members for the best papers produced. Now it is argued that it is hardly fair to place Juniors, under the age of thirty, in competition with men of forty, or fifty, or sixty years, who have reached advanced positions in the profession, who are men of known ability. Very probably such Juniors would not compete for the Junior prize, but they might, and this gentleman thought that it was a case which demanded action on the part of the Society. I may say further, without any violation of confidence, that he gave a good deal of consideration to the legal question that was raised by our worthy President, and he came to the conclusion that the Society had an undoubted right, legal and moral, to make this transfer. I say this on behalf of the gentleman, although I am not personally prepared to advocate the amendment very strongly.

Mr. CROWELL.—Mr. Chairman, there is a confusion, I think, in this matter, because the classification of Junior before the adoption of this Constitution was decidedly different from the classification of Junior at the present time. At the time this Constitution was adopted the clause which has been referred to was inserted in order to avoid the infringement of the rights of the class of Juniors that had been elected previously under the old Constitution. In my judgment, sir, we have no legal right to make any change in this matter. It is a right that has been secured to those men who came in under a certain classification, which was a higher classification, as I remember it, than the classification for Juniors at the present time; and we are bound in honor, as well as legally, in my judgment, to adhere to that contract. Besides that, it does not seem to me that there is any expediency in it. This is a very small class; it is an anomalous class, but it grew out of the condition of changing the classification of Juniors. I think we can

well afford to leave it alone. Perhaps some gentleman who may be a Junior under that old classification wishes he were not; and possibly some gentleman of that class—I have nobody in mind—may at some time run the gauntlet of getting into a higher class of his own motion. If he does not wish to, I think he should be left undisturbed. I do not think the Society has any right to attempt to move him. I think that clause should be left in just as it is.

Mr. Cohen.—I would like to add a word, Mr. President. The old Constitution, while it defined the requirements of a Junior, simply put no limit upon his connection with the Society. Now then, when limit was placed upon the continuance of a Junior, this clause which has been read and which it is now proposed to amend, provides that persons who were in the Junior class at the time of the adoption of this Constitution should not have their status changed by the provisions of this Section. You cannot amend that clause so as to change its force. They are not to have their status changed by its provisions. You may do anything else that does not interfere; but alter that you cannot. No amount of amendment to it will change its force at all. I cannot see exactly what the object is in changing the status of these Juniors. If they do not see fit to apply for advanced grade, they probably have some good reason; either that they do not choose to run the gauntlet of an election, or some other reason—the saving of advanced fees, it may be. There is nothing that we can do, in my judgment, that will be lawful or proper to turn them out of that position. And when they are called an anomalous class, they are a perfectly lawful class by the creation of the Society, and although it is not desirable to have half a dozen men in a different and distinct class from all the others, yet we have created them as such, and so long as they do not see fit to ask to have a change, we must let them alone. We cannot disturb them, in my view.

Mr. Crowell.—One word more. Nature will take care of the question before many years, sir. (Laughter.)

The President.—There is one word further to be said about this Clause 6. The addition to Section 6 of Article II of this clause, or its elimination, has nothing whatever to do with the legal status of the men who were Junior members at that time. We simply express it here, and that is all. If it is eliminated, they have the same legal right to remain Juniors that they have with it in. You might, of course, and the only thing you can do, it seems to me, is to provide a more easy way for these Juniors to change their status voluntarily. That is the only thing you can do, in my opinion —not as your President, but simply as an ordinary member of the Society.

R. S. Buck, M. Am. Soc. C. E.—In line with what you have just stated, Mr. President, I would like to offer an amendment to Major

Discussion on Amendment to Constitution (continued).

Knap's amendment, which changes the closing sentence of Section 6 of Article II to read as follows:

"The Board of Direction may change the grade of any Junior with his consent to whatever grade to which he is eligible."

That does away with several objections. In the first place, it does away with special legislation against that particular class. In the second place, it obviates the necessity of bringing a man before the Society for balloting a second time, and I think that the Board of Direction can be entrusted with the judgment of a man's case in that particular. As I understand it, he will go out on the Blue List and the Board will be open to any objection just as if he were to be voted on. It seems to me that would relieve the situation of the embarrassment which now seems to surround it.

Mr. Cohen.—Can I ask to have that proposed amendment read again?

Mr. Buck.—"The Board of Direction may change the grade of any Junior, with his consent, to whatever grade to which he is eligible."

Mr. Crowell.—Any Junior, or the Junior of a particular class?

Mr. Buck.—No, any Junior, the grade of any Junior.

The President.—That makes no discrimination whatever. Are there any remarks on this amendment to the amendment of the proposed amendment?

G. S. Williams, Assoc. M. Am. Soc. C. E.—I would rise to a point of order. If I remember, an amendment to an amendment is about as far as you can go. While I would be glad to endorse and second the last amendment proposed, I think it is out of order in that form.

The President.—This is only the second amendment. The Chair rules that it is in order. Any further remarks on it?

Palmer C. Ricketts, M. Am. Soc. C. E.—The difficulty about the original amendment, it seems to me, would be that a Junior is or may be a practicing engineer, and that an Associate is not intended—that class is not intended to be for practicing engineers, and I do not see that we have any right to change a man who may be a practicing engineer into a class which certainly is not intended—although I forget the exact wording of the Constitution—to be a class for practicing engineers. I do not think we have any moral right to do anything like that.

Mr. Buck.—It seems to me that the provision "with his consent" covers all of that. If a Junior objects to being made an Associate, he certainly cannot be made an Associate.

Mr. Ricketts.—I was not criticising your amendment. I was criticising the original amendment. As far as your amendment is concerned, I think it is open to this criticism, that it gives the Board the right to change the status of a member without submitting the ques-

tion to a vote of the members, because you include all Juniors. That point will have to be considered.

Mr. Gould.—I think that the gentleman who has last spoken perhaps confuses Associates with Associate Members.

Mr. Ricketts.—Not at all. No confusion at all. The original amendment, as I understand it, would transfer these Juniors, not to Associate Membership, but to Associates.

The President.—It would transfer them to such grade as they may be qualified for.

Mr. Ricketts.—No; the original one I am talking about. The original amendment, as suggested by Mr. Morison, is that they should be taken up bodily and made Associates, whether they want to or not.

The President.—I will read that. This is the original proposition: "The Board of Direction may transfer any Junior elected prior to March, 1891, to the grade of Associate."

Mr. Ricketts.—You take a practicing engineer then, and transfer him without his wish into a grade which is provided for men who are not practicing engineers. I do not think that the Society has any moral right to do anything of that nature.

Mr. Gould.—One moment. I would acknowledge to Professor Ricketts that I was mistaken. His remarks were applicable to the amendment to which he refers. It was one of several amendments.

Allen Hazen, M. Am. Soc. C. E.—Mr. President, as I understand it, the Board of Direction now has the power to elect any of these gentlemen Associates with their consent. It is unnecessary to amend the Constitution to secure that. I feel strongly the force of what Mr. Crowell has said and of what Mr. Cohen has said, and it seems to me that we should go very carefully indeed in touching what may be a contract——

The President.—Mr. Hazen, I would like to make a remark to you and the rest of the gentlemen here, and that is that in the discussion now, in order to avoid confusion in the minds of the members, I think your remarks for and against should be confined to the amendment to the amendment which we are now discussing, and you ought not to discuss the original amendment which will come up later on. That is simply a suggestion I would like to have the members keep in mind clearly. If your argument is against any one of these amendments, state specifically the one which you refer to.

Mr. Hazen.—I do not think that I have anything to say as to the amendment to the amendment, sir.

Mansfield Merriman, M. Am. Soc. C. E.—Mr. President, I rise to make the point of order that the amendment to the amendment is not a pertinent one and therefore not in order at this time. An amendment has been proposed relating to Juniors that are in a special class, namely, those elected prior to March, 1891; and therefore any amend-

Discussion on Amendment to Constitution (continued).

ment which goes into the question of all the Juniors or of the Associates or of the Associate Members, is not pertinent to the original resolution and therefore not in order.

The PRESIDENT.—The Chair would decide that the amendment is pertinent.

G. W. TILLSON, M. Am. Soc. C. E.—As I understand Mr. Buck's proposed amendment to the amendment, it would allow the Board of Direction to elect a Junior directly to full membership; is that so?

The PRESIDENT.—No, sir.

The SECRETARY.—I can explain that perhaps. A Junior ceases to be a Junior when he becomes thirty years of age, under our present Constitution, and a person is not qualified to be a Member until he is thirty. Consequently a Junior cannot be transferred to the grade of Member.

Mr. TILLSON.—Will not the wording of that amendment make him eligible to full membership?

The SECRETARY.—No, because he ceases to be a Junior when he becomes thirty.

Mr. CROWELL.—I should like to ask whether under the present Constitution the Board of Direction has not already the power to elect an Associate?

The SECRETARY.—Yes, sir; they have.

Mr. CROWELL.—What is the use of the amendment? If they propose to elect him as an Associate, they can do it after he ceases to be a Junior, as well as immediately before.

Mr. COHEN.—I would like to add one word. While I do understand the force of Mr. Buck's amendment to be that the Board may transfer, with his consent, a Junior to such class as the Board may see fit——

The PRESIDENT.—As he may be qualified for.

Mr. COHEN.—As he may be qualified to fill—with his consent. Now there is an express stipulation that Juniors who have been elected since this Constitution took effect will cease to be Juniors when they are thirty years of age. I have not recognized, and I am not sure that I recognize now that this provision, if carried, will authorize the Board to transfer any Junior to the advanced grade of full Member; but I would provide, for the very limited number of Juniors who are said to be in a class by themselves, that the Board should be empowered to transfer to any class for which they were eligible, with their consent, such members, by their action and without reference to the Society at large. If the amendment as presented does not cover quite that ground, I should like to see it amended to meet that point. All that they are pretending to deal with now is with a certain very limited number of Junior members, and if the Board be authorized to transfer them, with their consent, to any grade for

which they are eligible, you cover the whole thing. It may leave one or two who cannot be transferred, but that cannot be helped.

Mr. R. S. Buck.—It seems to me, that in view of the fact that the age of thirty years is the limit at which a person must cease to be a Junior, and at which he becomes eligible to full membership, that this would apply, without any further provision, to that particular class of Juniors who have reached the age of thirty, and who are otherwise qualified for full membership.

Mr. Whinery.—Mr. President, it, of course, is obvious to the membership that this amendment to the amendment defeats the object of the original amendment. Whether, therefore, it is pertinent or not, is a point of order that might be taken.

The President.—Take an extreme case, Mr. Whinery, in explanation of my ruling: An amendment to any resolution striking out the enacting clause is always pertinent, and you could not make any more radical change than by striking out the enacting clause. Now we simply do by indirection what would be perfectly in order to do by direction.

Mr. Whinery.—I should object very strongly to the proposed amendment to the amendment for this reason: We had some talk here this morning about the care that is taken in admitting members to the Society. There is no question but that there is very much less care taken in the case of Juniors than in any other class; for the reason that the intent of the Constitution was to make the provision so broad that young men, graduates of engineering schools, could come in, and in that way enter the profession. The door has been made wide open for them. Now it does not seem to me proper that we should change the whole tenor of the Constitution in that respect, should make such a sweeping change as to transfer members from this class into any class to which they may be eligible. The Board, under that amendment, might pass a Junior directly to the grade of Member. The Constitution in its present form makes ample provision for the advancement of members through the various grades. I should certainly oppose any sweeping change like that. (Applause.)

L. L. Tribus, M. Am. Soc. C. E.—I am opposed to the amendment to the amendment, but I think our matter goes farther back than the present discussion, in the original change of the Constitution. I think that the amendment to the Constitution as proposed should have been compulsory on the Board of Direction or on the membership to transfer those Juniors at the time of the change of Constitution, to the grade of Associate Member. I should be strongly in favor of changing the proposed amendment and making it compulsory on the Board of Direction to change those Juniors who were members of the Society at the time of the change of the Constitution, at once, to the grade of Associate Member, merely trying to give them the status that they

Discussion on Amendment to Constitution (continued).

did not have at the time of the adoption of the Constitution. It seems to me that they were degraded at that time and that error has never been corrected before. I think that giving the Board the right to transfer to any grade would certainly be a mistake.

Mr. Whinery.—I merely rise to correct the statement I made. My attention has been called to the fact that under this amendment to the amendment it would not be possible to transfer Juniors from the grade of Junior directly to the grade of Member, as I said.

Mr. Crowell.—I should like to ask if it is possible for the Secretary to inform us how many individuals were in this class of Juniors that were Juniors before 1891.

The Secretary.—At the time of the first agitation of this question, some five months ago, I think it was, there were twenty odd. Since that time there have been one or two resignations and two or three transfers. I should say now that there are, perhaps, sixteen or seventeen in that grade—not more.

Henry Manley, M. Am. Soc. C. E.—It seems to me that this last amendment, if it is likely to pass, is injudicious in this respect: Any one reading the amendment would fall into the same error that Mr. Whinery did, and that I did when I first heard it. On the face of it, it allows of a transfer of a Junior member to any position to which he is eligible. He may be eligible by natural talent to that position, whereas others would have to stand and wait. But it is discovered that in another remote part of the Constitution there is a provision forbidding that. It seems to me it is injudicious in form and should be voted down.

The President.—Our time is short, gentlemen, and I believe this matter has been fully discussed. If we can find that amendment we will have it read to you before we vote on it. Will the Secretary please read the amendment to the amendment?

The Secretary (reading).—"The Board of Direction may change the grade of any Junior, with his consent, to whatever grade to which he is eligible."

The President.—Is that all?

The Secretary.—It seems to be all, sir.

The President.—The vote is now on the amendment to the amendment of the original proposition to amend the Constitution. All in favor of this amendment will signify by saying Aye; contrary, No.

The amendment was lost.

The President.—The vote is now on the amendment to the proposed amendment to the Constitution suggested by Mr. Knap. Will the Secretary please read it?

The Secretary (reading).—"Strike out the final sentence of Section 6 of Article II, reading: 'Persons who are in the Junior class at the

time of the adoption of this Constitution shall not have their status changed by the provisions of this section,' and substitute therefor the following: 'Persons who became Juniors on or before the date of the adoption of this Constitution may be transferred to other classes of membership by the Board of Direction. Until so transferred they shall continue to be Juniors.' "

The PRESIDENT.—All in favor of this amendment will signify by saying Aye; all opposed, No.

The amendment was lost.

The PRESIDENT.—The vote is now on the original proposition to amend the Constitution which is as follows—that is, I mean, whether it shall be sent to letter-ballot. The Secretary corrects me. The proposed amendment reads as follows:

"Amend Section 5 of Article II by adding the following: 'The Board of Direction may transfer any Junior elected prior to March 4th, 1891, to the grade of Associate.' "

All in favor signify by saying Aye; contrary, No. It is lost.

The SECRETARY.—I think, sir, that this meeting has no option whatever in this matter. The Constitution provides that an amendment to the Constitution shall be presented at a certain time and shall come up for discussion at one of the general meetings of the Society. If amended, it shall be sent out to letter-ballot in amended form. If not amended, it shall be sent out in the original form.

The PRESIDENT.—Gentlemen, we stand corrected. There is nothing to do except to follow the Constitution and send this proposed amendment out to letter-ballot unless it is amended. The Secretary will read the clause in the Constitution.

The Secretary read the clause in the Constitution relating to amendments.

F. P. STEARNS, M. Am. Soc. C. E.—Is it in order to ask a question?

The PRESIDENT.—Yes, sir.

Mr. STEARNS.—Can this meeting give an expression of opinion as to whether it is expedient to pass the amendment, so that with the ballot might go out the expression of opinion of this meeting?

The PRESIDENT.—I do not think so—any more than the meeting has already expressed itself.

Mr. STEARNS.—That expression of opinion, which I believe is on record, as to the original amendment——

The PRESIDENT.—This meeting, of course, could pass a resolution instructing the Secretary to say that it was the sense of the members assembled in Annual Meeting that they were not in favor of this proposition.

Mr. STEARNS.—That is what I was proposing.

The PRESIDENT —There would have to be a resolution made, of course, to that effect and regularly passed.

Discussion on Amendment to Constitution (continued).

Mr. Stearns.—I intended to make that resolution. You have worded it substantially as I intended.

The President.—Is there a second to that?

A member seconded the resolution.

The President.—Will the gentleman kindly write his resolution out? I believe you all understand the resolution thoroughly. It is that the Secretary be instructed to inform the members when this proposed amendment is sent out to letter-ballot that it is the sense of this meeting that it be not adopted. Is that correct?

Mr. R. S. Buck.—With a statement of the vote, Mr. President.

Mr. Crowell.—It seems to me that a statement of fact that it was discussed and what happened here is proper. It does not seem to me that this meeting has exactly the right to instruct the membership of this Society at large, and it would look like an attempt to do it. I think that the mere recital of the facts in regard to this question would be in order and proper.

Mr. Buck.—It seems to me that a recital of the facts would certainly include what the vote was. To say that the meeting was in favor of it, without stating how many voted or how many voted each way, would give, it seems to me, the adequate information.

The President.—It is in the hands of the meeting to indicate how it desires to express its opinion, whether by ayes and noes, or simply by majority vote.

John F. O'Rourke, M. Am. Soc. C. E.—A man could have become a Member three or four times over, although he was ineligible for anything but Junior, since this discussion was begun. It seems to me it is a matter which will settle itself. These Juniors will all die sometime, and this discussion will go on. I should prefer to leave out all mention in the letter-ballot of what has been done. Suppose we are a little bit wiser than anybody else, and want to tell the other fellows what to do—they get that without cost in the *Proceedings*. Anybody that reads the *Proceedings* will know that this was voted upon here and voted down. Perhaps we could find out those who do not care to read the *Proceedings*, and send them a little private letter telling them how the vote was. But it strikes me the most dignified way to treat this matter is to drop it at this meeting, and let it go through the regular channels.

A Member.—I want to ask one question, with your permission—whether a further amendment to the amendment would be in order?

The President.—Certainly, you can amend here all day.

A Member.—An amendment has been suggested which I think would meet the approval of a number—to add the word "Member"; make it read "Associate Member" instead of "Associate."

The President.—Is there any second to the amendment?

No one seconded the amendment.

The PRESIDENT.—The resolution is in order. All in favor of the resolution signify by saying Aye; contrary, No.

The resolution was lost.

Appointment of Nominating Committee.

The PRESIDENT.—The next business is the selection of the Nominating Committee. By a recent amendment to the Constitution, the appointment of seven members of the Nominating Committee, which has heretofore been made at the Annual Convention, is to be similarly made hereafter at the Annual Meeting. A circular was duly sent out asking for suggestions for representatives of the seven districts on this Committee, and the Secretary has a report of the returns received.

The Secretary read the nominations for District No. 1, as follows:

District No. 1.—Total number of votes received, 39; as follows:

IRA A. SHALER	18
R. S. BUCK	4
EDWARD P. NORTH	2

The following, one each:

WM. HENRY BALDWIN,	CHAS. MACDONALD,
H. W. BRINCKERHOFF,	O. F. NICHOLS,
WM. H. BURR,	H. G. PROUT,
THEODORE COOPER,	MAX E. SCHMIDT,
ALFRED CRAVEN,	S. C. THOMPSON,
HENRY GOLDMARK,*	JOHN C. WAIT,
HENRY W. HODGE,	J. WALDO SMITH,
WM. R. HUTTON,	S. C. WEISKOPF,

WM. J. WILGUS.

The PRESIDENT.—These names are simply suggestions, as I understand it, to this meeting, to enable the meeting to know the opinion of the members residing in the district. Is that right, Mr. Secretary?

The SECRETARY.—It is in the power of this meeting to elect any one.

The PRESIDENT.—It is in the power of this meeting to elect any one. It has been customary to consider the candidate receiving the highest number of votes as the nominee, unless there are other nominations. Is a regular motion necessary?

The SECRETARY. —I think so; yes, sir.

The PRESIDENT.—A regular motion, however, is necessary to put Mr. Shaler's name in nomination or any other representative of District No. 1.

A MEMBER.—I nominate Mr. Shaler. (Seconded.)

The PRESIDENT.—Are there any other nominations? If not, all in favor of Mr. Shaler being on the Nominating Committee from District No. 1, will signify by saying Aye; contrary, No.

The motion was carried.

The PRESIDENT.—Mr. Shaler is appointed.

The Secretary read the nominations from District No. 2, as follows:

* Ineligible.

Appointment of Nominating Committee (continued).

District No. 2.—Total number of votes received, 39; as follows:

S. E. Tinkham	14
F. S. Curtis	3
Desmond FitzGerald*	2
Richard A. Hale	2
C. Frank Allen	2
Geo. A. Kimball	2
Henry Manley	2
Geo. F. Swain	2
J. P. Snow	2

The following, one each:

A. S. Cheever,	Frank O. Maxsen,
Frederic Danforth,	C. B. Vorce,
John R. Freeman,	J. R. Worcester,
X. H. Goodnough,	Edwin P. Dawley.

Mr. Crowell.—I move the gentleman having the greatest number of votes be appointed on the Committee.

The Secretary.—That is Mr. Tinkham.

The motion was seconded.

The President.—It is moved and seconded that Mr. Tinkham be elected a member of the Nominating Committee from the Second District. All in favor signify by saying Aye; contrary, No.

The motion was carried.

The President.—Mr. Tinkham is elected.

The Secretary read the nominations from District No. 3, as follows :

District No. 3.—Total number of votes received, 25; as follows:

John F. Alden	4
Edw. B. Guthrie*	3
Elnathan Sweet	3
Louis H. Knapp	2
T. C. Leutze	2

The following, one each:

Wm. B. Cogswell,	Wm B. Landreth,
C. L. Crandall,	W. G. Raymond,
W. A. Haven.	Richard W. Sherman,
Edmund Hayes,	T. Guilford Smith,
Emil Kuichling,	T. W. Symons,

W. G. M. Thompson.

Mr. Crowell.—I move that the highest one, Mr Alden, be appointed. (Seconded.)

The President.—Are there any other nominations? It is moved and seconded that Mr. Alden be elected a member of the Nominating Committee from District No. 3. All in favor signify by saying Aye; contrary, No.

The motion was carried.

The President.—Mr. Alden is elected.

---

* Ineligible.

The Secretary read the nominations from District No. 4, as follows:

District No. 4.—Total number of votes received, 50; as follows:

Paul L. Wölfel	13
L. Y. Schermerhorn	9
Mansfield Merriman	4
Geo. S. Davison	4
Kenneth Allen	2
Chas. G. Darrach	2
Alexander Mackenzie	2
Thomas Rodd	2
C. C. Schneider	2

The following, one each:

Arthur P. Davis,	Henry G. Morse,
C. B. Dudley,	Samuel Rea,
Thos. H. Johnson,	Emil Swensson,
Charles H. Latrobe,	Geo. E. Thackray,
David E. McComb,	Theo. Voorhees,

Wm. R. Webster.

A Member.—Mr. President, I move that Mr. Paul L. Wölfel be elected a member of the Nominating Committee for District No. 4. (Seconded.)

Mr. Cartwright.—How many votes did Mr. Wölfel have?

The Secretary.—Thirteen.

The President.—Any other nominations? All in favor of the election of Mr. Wölfel as member of the Nominating Committee for District No. 4 will say Aye; contrary, No.

The motion was carried.

The President.—Mr. Wölfel is elected.

The Secretary read the nominations from District No. 5, as follows:

District No. 5.—Total number of votes received, 41; as follows:

Frank C. Osborn	3
Onward Bates	2
G. B. Nicholson	2
Alfred Noble*	2
Chas. L. Strobel*	2
John F. Wallace*	2
Walter P. Rice	2

The following, one each:

G. Bouscaren,	R. L. Read,
D. D. Carothers,	H. E. Riggs,
Edw. C. Carter,*	James Ritchie,
B. L. Crosby,	Samuel Rockwell,
Chas. E. Greene,	L. W. Rundlett,
E. A. Handy,	John H. Sample,
Horace E. Horton,	E. C. Shankland,
Wm. H. Hughes,	A. V. Sims,
Wm. C. Jewett,	Cady Staley,
Geo. W. Kittredge,	John F. Stevens,
Wm. de la Barre,	Job Tuthill,
G. A. Marr,	Chas. A. Wilson,
Ralph Modjeski,	Geo. Y. Wisner.

*Ineligible.

Appointment of Nominating Committee (continued).

The SECRETARY.—Of the gentlemen whose names were first read, it is quite likely that the one having the highest number of votes will be a member of the Board of Direction—he may be, at all events—Mr. Osborn; and Mr. Noble, Mr. Strobel, Mr. Wallace and Mr. Carter are ineligible.

A MEMBER.—Who is the next?

The SECRETARY.—Mr. Onward Bates.

The MEMBER.—I nominate Mr. Bates.

Mr. CROWELL.—I second the motion.

The PRESIDENT.—All in favor of Mr. Onward Bates being elected member of the Nominating Committee from District No. 5 will signify by saying Aye; contrary, No.

The motion was carried.

The PRESIDENT.—Mr. Bates is elected.

The Secretary read the nominations from District No. 6, as follows:

District No. 6.—Total number of votes received, 32; as follows:

B. L. CROSBY	4
R. MONTFORT	3
JAMES P. ALLEN	2
CHAS. S. CHURCHILL	2
GEO. G. EARL	2
EDWARD FLAD*	2
J. A. OCKERSON	2

The following, one each:

C. P. E. BURGWYN,	HUNTER MCDONALD,
W. M. BLACK,	F. A. MOLITOR,
D. BONTECOU,	S. F. MORRILL,
W. H. COURTNEY,	GEO. B. NICHOLSON,
W. B. W. HOWE, Jr.,	JOS. RAMSEY, Jr.,*
B. M. HARROD,*	ANDREW ROSEWATER,
J. F. HINCKLEY,	A. M. SCOTT,

W. V. JUDSON.

Mr. CROWELL.—I move the first name on the list.

(Seconded.)

The PRESIDENT.—Any other nominations?

ALFRED W. TROTTER, M. Am. Soc. C. E.—I would like to nominate Mr. Montfort. I think it would be very advantageous to the Society to secure his services.

The PRESIDENT.—Gentlemen, you have heard two names. I will put Mr. Crosby's first as he was nominated first. All in favor of Mr. Crosby being elected member of the Nominating Committee from District No. 6, hold up their right hands.

Twenty-eight members held up their right hands.

The PRESIDENT.—All in favor of Mr. Montfort will signify by holding up their right hand.

Twenty-eight members voted for Mr. Montfort.

* Ineligible.

The SECRETARY.—You have the deciding vote, sir.

The PRESIDENT.—I shall decide in favor of Mr. Montfort for the reason that I think he represents, on account of his position of Chief Engineer of the Louisville and Nashville, and his age, probably a larger number of the members of the Society in that district than Mr. Crosby, although either one of those gentlemen would be abundantly fitted and qualified for a position on the Nominating Committee.

The Secretary read the nominations from District No. 7, as follows:

District No. 7.—Total number of votes received, 21; as follows:

ARTHUR L. ADAMS	2
W. W. FOLLETT	2
CHAS. D. MARX	2
A. S. RIFFLE	2

The following, one each:

F. W. BLACKFORD,	A. I. FRYE,
R. E. BRIGGS,	C. E. GRUNSKY,
H. ST. L. COPPEE,	J. HERRON,
W. G. CURTIS,	W. H. KENNEDY,
C. E. L. B. DAVIS,	M. L. LYNCH,
C. E. FOWLER,	ELWOOD MEAD,

M. H. ROGERS.

Mr. CARTWRIGHT.—Mr. President, in the interest of our Society in the far West I would suggest the name of Mr. Marx. He is a professor in Stanford University, and a man that can do the Society remarkable good in the West, and I would put his name in nomination.

A MEMBER.—I second the nomination.

Mr. R. S. BUCK.—May I ask the highest number of votes received for any gentleman?

The SECRETARY.—There were four gentlemen; each had two votes.

The PRESIDENT.—Any other nominations for the 7th District? Before putting this to vote, the Secretary informs me the hour of 12 o'clock is here, and I therefore declare the ballot closed. All in favor of Mr. Marx being elected member of the Nominating Committee to represent District No. 7, signify by saying Aye; contrary, No.

The motion was carried.

The PRESIDENT.—Mr. Marx is elected.

N. P. LEWIS, M. Am. Soc. C. E.—If I am in order I would like to say a word in behalf of the Nominating Committee. The Nominating Committee consists of 19 members, five of whom are Past-Presidents. At the last meeting of that Committee there were seven members present. Three districts were entirely unrepresented. Now I believe that the Nominating Committee is clothed with considerable discretion in presenting names to be balloted on for the general officers of the Society—President, Vice-Presidents at large and Treasurer; but when it comes to representation in the Board of Direction they should be guided very largely, if not entirely, by the expression of opinion from

the members of each district. It has been found impossible to get such an expression of opinion when so small a minority of the Committee have been present, and it has been necessary to have their action confirmed by correspondence, which has taken a good deal of time and has been somewhat laborious. It is to be hoped that at the Annual Convention next summer a much larger representation of the Committee can be had, but I think it is the duty of the members of the Society to get into communication with the member of the Nominating Committee from their district, and I think I may promise that the Membership Committee between now and the Annual Convention will endeavor to obtain an expression of opinion from the membership of the Society at large; but I do not think the membership ought to wait to be solicited for such an expression, but they should put the member of the Nominating Committee more in touch with themselves, and should put in his possession any suggestions, both for nominations for the general officers of the Society, and especially for nominations for the Board of Direction to represent that district, and I sincerely hope that the members here present will bear that in mind and try to help the Nominating Committee as much as they can to submit names which will be entirely representative, and which will also meet with the hearty approval of the membership in the various districts. (Applause.)

Report of Committee on Cement.

The PRESIDENT.—Gentlemen, we have a Standing Committee from whom we have not had a report for some time. I refer to the Committee on Cement. I believe the Chairman, Prof. George F. Swain, is present, and perhaps can furnish us with a progress report.

GEORGE F. SWAIN, M. Am. Soc. C. E.—Owing to circumstances which have prevented the Chairman of the Committee from devoting much time to the work during the past year, the Committee is not able at this time to submit any formal report, although it has made some progress, and has a large amount of work blocked out.

That is all that the Committee has to say; but in my individual capacity I have two remarks to make. The first is, that if any members of the Society are disposed to complain of the slow progress of the Committee, they should put the blame directly on the Chairman, because it is owing to him that so little has been done in the past year. The second thing is this: The Committee as originally appointed consisted of seven members. One has since resigned from the Society, leaving six. Some members of the Committee at least have thought that it would be very desirable if the chemist and manufacturer could have some representation. I am not sure what action was taken by the Society when it passed the original resolution to appoint the Committee as to whether the number of the Committee should be limited, and the members of the Committee are not agreed as to whether the number of the Committee should be increased.

The vacancy, I presume, should be filled and will be filled; but it might be desirable—I simply bring it before the Society—it might be desirable, perhaps, to authorize the Board of Direction to increase the Committee if they should think it desirable.

The PRESIDENT.—Is there any motion to that effect?

E. B. CODWISE, M. Am. Soc. C. E.—I move that the Committee have the power to increase its number if it so desires. (Seconded.)

The PRESIDENT.—Are there any remarks on the motion?

PROF. SWAIN.—I did not hear the motion.

The PRESIDENT.—The motion was that the Committee be given the power to increase its membership to such an extent as it may desire. Any remarks on that motion? All in favor signify by saying Aye; contrary, No.

The motion was carried.

Meeting of Board of Direction.

The SECRETARY.—The report of the tellers will be ready in a very few minutes. The programme says that at one o'clock lunch will be served, and if necessary this meeting will be resumed. We hope that will not be necessary. I think, Mr. President, you had better fix an hour, as soon after lunch as possible—say half-past one—for the meeting of the Board of Direction.

The PRESIDENT.—The meeting of the Board of Direction will take place immediately after this meeting and before lunch (laughter). One of the fundamental principles, you know, of engineers, particularly the old ones, in which class I presume I can now consider myself, is to finish our work before we eat (laughter).

Programme of Annual Meeting.

The SECRETARY.—As to the excursions which have been arranged for this afternoon, we will view the work of the Rapid Transit construction. While we are eating lunch we will try to form some plan by which the parties can be gotten together. There are several members of the Society engaged on that work who have kindly offered to go with parties and show them what there is to see, one party going to the North and one going to the South; and it has been suggested, and I think will be carried out, that a special car will be ready at a certain time—I am not prepared to say now what that hour will be—but before the lunch to-day is over I think we will be able to say just how each person who wishes to see this work shall go about it.

The reception this evening will be at 9 o'clock, and it is hoped that as many ladies will come as there are members present.

The excursion to-morrow will leave promptly at 10 o'clock from West Fifty-seventh Street. The steamer *Valley Girl*, which has been obtained through the courtesy of Mr. John H. Starin and General Howard Carroll, will leave promptly—I repeat it—because we have a good deal to see, and it is necessary that we should be prompt. During the day luncheon will be served on the boat, and a stop will be made

Programme of Annual Meeting (continued).

at one or more points where the work of the Department of Docks and Ferries is now going on on the East River.

By invitation of Mr. Thomas E. Murray, General Manager of the New York Gas and Electric Light, Heat and Power Company, and J. W. Leib, Jr., M. Am. Soc. C. E., General Manager of the Edison Electric Illuminating Company, and Mr. John Van Vleck, Constructing Engineer of both companies, a party will visit the Water-Side Power Station at Thirty-eighth Street, East River. A stop will also be made, by invitation of George H. Pegram, M. Am. Soc. C. E., Chief Engineer at the new power station of the Manhattan Railway Company at Seventy-fourth Street, East River.

To-morrow night at 8.30, in this room, Elwood Mead, M. Am. Soc. C. E., Expert in Charge of Irrigation Investigations, United States Department of Agriculture, will describe irrigation methods in use in the arid regions, showing lantern slides, of unirrigated and irrigated lands in that region, some of the canals and head-gates of irrigation systems, the apparatus used in the Department in the investigations of the duty of water, and the results of these studies. After that lecture there will be a smoker.

Mr. J. H. Granbery, Junior of the Society, Engineer in Charge of Construction of the Arlington Copper Company, has extended an invitation to those members who are specially interested in works of that kind, to visit the works of that company at Arlington, N. J., on Friday, at any time which suits their convenience. Arlington is 30 minutes from the foot of Chambers Street *via* the New York and Greenwood Lake Branch of the Erie Railroad, and it is about a mile from the station to the works. I asked Mr. Granbery if he would state what was the best time to go out there, and he sent me some time tables. An examination of them leads to the belief that the best train is the one which leaves at 9.40 in the morning from Twenty-third Street, 9.45 from Chambers Street. That train gets to Arlington at 10.15; and if such members as desire to view those works (and quite a number have informed the Secretary that they would like to go) will go on that train, I will try and arrange it with Mr. Granbery that they shall be met and taken through the works. I understand that it will take about two hours after reaching the works to go through the mines.

Invitation to Inspect Foundations of Mutual Life Building.

Mr. President, I have a letter here which I would like to read.

New York, January 9th, 1901.

Charles Warren Hunt, Esq.,
Secretary, Am. Soc. C. E.,
220 West Fifty-seventh Street, N. Y.

Dear Sir,—Thinking that some of the members attending the annual meeting might be interested in the pneumatic foundations now in progress for the Mutual Life Building at 55 Cedar Street, the contractors, Arthur McMullen & Co., and the architects, Messrs. Clinton and Russell, Major J. Hollis Wells, Engineer, desire me to

state that they would be glad to show any of the members over the work. If we are notified in advance, Major Wells and Mr. McMullen will be on hand to explain.

The foundations are carried to rock about 100 ft. below the curb, or 80 ft. below water at deepest point, on 35 rectangular caissons and 46 circular caissons, including those used to support old walls. The rectangular caissons form an 8-ft. wall around the entire lot (which is 16 000 ft. square), and after this retaining wall is completed the cellar will be excavated to a depth of about 35 ft. below standing water while the iron work of the building is being erected. The erection of iron has now begun on the Cedar Street end and 65 of the caissons are completed.

There are many interesting features about the work, including the ramming of clay between the caissons to hold the water back while excavating the cellar.

Yours truly,

T. Kennard Thomson, M. Am. Soc. C. E.,
Engineer for Contractor.

I am just informed that it will be about ten minutes before the report of the tellers is ready.

A Member.—I move that a recess of ten minutes be taken.

Recess.

The President.—Gentlemen, we have about ten minutes before we will hear the report of the tellers, and new business is in order; and if any member has anything to suggest or any motion to make for the good of the Society, I presume that we will have time enough to consider it.

Henry G. Prout, M. Am. Soc. C. E.—It is Mr. O'Rourke's suggestion that we might have a discussion on Standard Time (laughter).

The President.—If there is no objection we will take a recess for ten minutes, without leaving the room or your seats. In other words we will "rest arms."

(Recess.)

Report of Tellers.

The President.—Will the gentlemen back near the door inform the gentlemen in the library that recess is ended? The Secretary will now read the report of the tellers.

The Secretary read the tellers' report respecting the vote for President.*

The President.—I have the pleasure, gentlemen, to announce the election of Mr. Croes as President of the Society for the ensuing year. (Applause.) The Secretary will now go through the remainder of the list.

The Secretary read the vote for Vice-Presidents.

The President.—Messrs. Haines and Benzenberg are elected Vice-Presidents for the next two years. (Applause.)

The Secretary announced the vote for Treasurer.

*For full report of the tellers, see page 58.

Report of Tellers (continued).

The PRESIDENT.—Mr. Knap is elected Treasurer for the ensuing year. (Applause.)

The Secretary stated the vote for Director from District No. 1.

The PRESIDENT.—Mr. Briggs is elected for the 1st District.

The Secretary stated the vote for Director for District No. 2.

The PRESIDENT.—Mr. Swain is elected Director from the 2d District.

The Secretary stated the vote for Director for District No. 3.

The PRESIDENT.—Mr. Kuichling is elected Director from the 3d District.

The Secretary stated the vote for Director for District No. 4.

The PRESIDENT.—Mr. Endicott is elected Director from the 4th District.

The Secretary read the vote for Directors for District No. 5.

The PRESIDENT.—Mr. E. C. Carter and Mr. F. C. Osborn are elected Directors from District No. 5.

Report of Tellers Appointed to Canvass the Ballot for the Election of Officers at the Annual Meeting, January 16th, 1901.

Whole number of ballots received	616
Without signatures	6
Counted	610
For President:	
J. James R. Croes	592
Robt. Moore	6
Theodore Cooper	1
Jas. Dun	1
Clemens Herschel	1
Rudolph Hering	1
Ed. P. North	1
F. P. Stearns	1
John M. Wilson	1
Defective	1
Blank	4
For Vice-Presidents:	
Henry S. Haines	589
Geo. H. Benzenberg	592
Alexander Mackenzie	25
Howard G. Kelley	2
Geo. S. Webster	2
Geo. A. Quinlan	1
John G. Van Horne	1
Defective	2
Blank	6
For Treasurer:	
Jos. M. Knap	606
John Thomson	2
Jas. H. Fuertes	1
Blank	1

For Directors:

District No. 1:

Josiah A. Briggs	605
C. C. Upham	1
Blank	4

District No. 2:

George F. Swain	605
Geo. B. Francis	1
Geo. A. Kimball	1
Henry Manley	1
Blank	2

District No. 3:

Emil Kuichling	604
John F. Alden	1
Wm. A. Brackenridge	1
Blank	4

District No. 4:

Mordecai T. Endicott	603
Lewis M. Haupt	1
Jas. H. Harlow	1
Blank	5

District No. 5:

Edward C. Carter	389
Frank C. Osborn	282
Wm. H. Searles	241
Defective	287
Blank	21

WM. B. FULLER,
OSCAR ERLANDSEN,
OSCAR LOWINSON,
Tellers.

JANUARY 16th, 1901.

The PRESIDENT.—Gentlemen, before drifting into the past, I desire to thank you for the honor that you did me a year ago, and for the courteous and kind treatment that I have received at your hands. I will now ask that Mr. Hering bring forward the President-Elect. (Applause.)

Mr. Hering escorted President Elect Croes to the platform.

President Croes Introduced.

PRESIDENT WALLACE.—In laying aside this gavel, it gives me pleasure to know that I am to be succeeded by so worthy a man as Mr. Croes, who needs no introduction to you. (Applause.)

J. J. R. CROES, President, Am. Soc. C. E.—Gentlemen, I desire to express my sincere thanks to you and my high appreciation of the honor conferred upon me. My only fear in the matter is that I shall not be able to fill the position with the efficiency and dignity shown by my immediate predecessor in the office, and by the long list of predecessors whose example is before me. I can only say that I trust that I may emulate them in the discharge of the duties of the office

I believe that the President does not assume the chair until the close of the Annual Meeting. However, I feel obliged, though with reluct-

ance, to change the ruling of my predecessor right here, and to announce that the meeting of the Board of Direction will be held after lunch instead of before. (Applause.) Gentlemen, a motion to adjourn is in order.

Mr. Crowell.—I move that we now adjourn.

The motion was carried and the meeting adjourned.

Thursday, January 17th, 1901.—The meeting was called to order at 8.30 p. m., President J. James R. Croes in the chair; Assistant Secretary T. J. McMinn, acting as Secretary, and present, also, 136 members and 28 guests.

Elwood Mead, M. Am. Soc. C. E., delivered a lecture, illustrated with the stereopticon, on irrigation methods in use in the arid regions of the United States.

Adjourned.

EXCURSIONS AND ENTERTAINMENTS AT THE FORTY-EIGHTH ANNUAL MEETING.

Wednesday, January 16th, 1901.—After the business meeting lunch was served at 1.30 p. m. in the Lounging Room. After lunch several parties were organized and visited the construction work of the Rapid Transit Railroad Commission, under the guidance of the engineers of that work.

At 9 p. m. a Reception was held in the Society House, which was largely attended.

Thursday, January 17th, 1901.—At 10.30 a. m. the steamer *Valley Girl* (kindly furnished for the occasion by John H. Starin, Esq., and General Howard Carroll), with about 350 members and guests, including many ladies, left the pier of the Department of Docks, at the foot of West Fifty-seventh Street, for an excursion. The steamer proceeded down the North River, around the Battery and up the East River. At the New York and Brooklyn Bridge and at the New East River Bridge speed was reduced in order to give an opportunity to view those structures. A stop was made at the foot of East Twenty-second Street, in order to inspect the work of the Dock Department at that place.

A stop was also made at Thirty-eighth Street, where the Water-Side Power Station of the New York Gas and Electric Light, Heat and Power Company was inspected. Another landing was made at Seventy-fifth Street in order to view the electric power station of the Manhattan Railway. Lunch was served *en route*, and the steamer then conveyed the party to the Recreation Pier at East Twenty-fourth Street.

At 8.30 p. m. Elwood Mead, M. Am. Soc. C. E., delivered a lecture

on irrigation methods in use in the arid regions of the West. The lecture was illustrated with lantern slides.

After the lecture there was an informal "Smoker," which was enjoyed by about 170 members and guests.

The following list contains the names of 319 members of various grades, who registered as being in attendance at the Annual Meeting. This list is incomplete, on account of the failure of many members to register, and it does not include the names of any of the guests of the Society or of individual members:

Aiken, W. A.....Pittsburg, Pa.
Aus, Gunwald ....New York City
Averill, F. L...Washington, D. C.

Bacon, John W..Danbury, Conn.
Baldwin, F. H....Bayonne, N. J.
Ballou, G. L.....New York City
Basinger, J. G.....New York City
Baum, George....New York City
Belzner, Theodore.New York City
Bensel, J. A.....New York City
Berg, Walter G....New York City
Bishop, G. H..Middletown, Conn.
Bissell, H.....Boston, Mass.
Boecklin, Werner, Jr.
New York City
Boggs, J. I.....Tie Siding, Wyo.
Boller, Alfred P...New York City
Boller, A. P., Jr.Brooklyn, N. Y.
Bontecou, D....Kansas City, Mo.
Bonzano, A.....Philadelphia, Pa.
Booth, W. F..Poughkeepsie, N. Y.
Bowman, A. L.....New York City
Boyd, Jas. C.....Boston, Mass.
Braine, L. F.....Brooklyn, N. Y.
Bramwell, G. W..New York City
Brinckerhoff, H. W. New York City
Brown, Le Grand, Rochester, N. Y.
Brown, T. E., Jr..New York City
Buck, H. R .Wethersfield, Conn.
Buck, L. L.....New York City
Buck, R. S.....New York City
Buck, W. E.....Worcester, Mass.
Burbank, Geo. B..New York City
Burdett, F. A....Brooklyn, N. Y.
Burns, Justin.....New York City
Burrows, Geo. L..Saginaw, Mich.

Carney, E. J.....New York City
Carr, Albert.....New York City
Cartwright, R....Rochester, N. Y.
Catt, Geo. W.....New York City
Chambers, R. H...New York City
Chase, F. L.....New York City
Chester, J. N. .....Pittsburg, Pa.
Christian, G. L....New York City
Clark, G. H.....New York City
Clark, John A., Jr..Orange, N. J.
Clarke, T. C.....New York City
Codwise, E. B....Kingston, N. Y.
Coffin, Amory.....New York City
Coffin, T. Amory
West New Brighton, N. Y.
Cogswell, W. B...Syracuse, N. Y.
Cohen, Mendes...Baltimore, Md.
Colby, S. K.....New York City
Cole, John A.....Chicago, Ill.
Cole, Howard J.East Orange, N. J.
Collier, B. C.....New York City
Cook, John H.....Paterson, N. J.
Cooper, S. L.....Yonkers, N. Y.
Cooper, Theodore.New York City
Corby, C. E.....Brooklyn, N. Y.
Cornell, Geo. B....New York City
Cornell, J. N. H...New York City
Corthell, A. B.....Boston, Mass.
Cotton, Joseph P..Newport, R. I.
Craven, Alfred....New York City
Creuzbaur, R. W..New York City
Croes, J. J. R.....New York City
Cudworth, F. G..Brooklyn, N. Y.
Cummings, Noah..New York City

Darrach, C. G. . . Philadelphia, Pa.
Davies, John V. . . New York City
Davis, Chandler. . . New York City
Davis, Charles. . . . Allegheny, Pa.
Davis, Chester B. . New York City
Davis, W. R. . . . . Albany, N. Y.
Day, Arthur M. . . . New York City
Dean, Luther. . . . Taunton, Mass.
Deans, J. S. . . . . Phœnixville, Pa.
DeWitt, Elmore. . . . Steelton, Pa.
Diebitsch, Emil. . . New York City
Dixon, D. H. . . . Milwaukee, Wis.
Duncklee, J. B. South Orange, N. J.
Dunham, H. F. . . . New York City

Edwards, J. H. East Berlin, N. Y.
Enos, G. W. . . . . New York City
Erlandsen, Oscar. New York City
Evans, Louis H. . . New York City
Evans, M. E. . . . . New York City

Farnum, H. H. . . . New York City
Farrington, H. . . . New York City
Felton, Herbert C. Camden, N. J.
Fisher, F. D. . . . . New York City
Frank, Geo. W. . . New York City
Frazee, J. H. . . . . New York City
Freeman, J. R. . Providence, R. I.
French, A. H. . . . Brookline, Mass.
Fuertes, James H. New York City
Fuller, Geo. W. . . New York City
Fuller, W. B. . . . . Boston, Mass.
Furber, Wm. C. . Philadelphia, Pa.
Furman, J. R. . London, England

Garrison, F. L. . Philadelphia, Pa.
Gartensteig, Chas. New York City
Gay, Martin . . . . . New York City
Gibbs, George. . Philadelphia, Pa.
Gifford, Geo. E. . . New York City
Gillespie, R. H. . . New York City
Goldsborough, J. B.
Croton-on-Hudson, N. Y.
Goodrich, W. F. Somerville, Mass.
Gould, E. Sherman. Yonkers, N. Y.
Graham, C. H. . . . . New York City
Gray, W. . . . . New York City
Green, B. R. . . Washington, D. C.
Greene, G. S., Jr. . New York City
Grimm, C. R. . . . . Elmira, N. Y.
Gudmundsson, G. . Pittsburg, Pa.

Haight, Stephen S. New York City
Hansel, Charles. . . New York City
Harrison, E. W. Jersey City, N. J.
Haskins, W. J. . . . . New York City
Hatton, T. C. . . Wilmington, Del.
Haviland, A. . . . . New York City
Hazen, Allen. . . . . New York City
Hemming, D. W. . . New York City
Hendrick, C. W. . . New York City
Herbert, H. M. Bound Brook, N. J.
Hering, Rudolph. . New York City
Hill, A. B. . . . . New Haven, Conn.
Hinds, F. A. . . . Watertown, N. Y.
Hoag, S. W., Jr. . . New York City
Hodgdon, F. W. . . . Boston, Mass.
Hodge, Henry W. . New York City
Hone, F. de P. . . . . New York City
Honness, G. G. . . . Paterson, N. J.
Hovey, O. E. . . . . Pencoyd, Pa.
Howard, J. L. . . . . Boston, Mass.
Hoyt, John T. N. . . . Albany, N. Y.
Humphrey, R. L. Philadelphia, Pa.
Hunt, Chas. W. . . . New York City
Hutton, W. R. . . . . New York City

Irving, Walter E. . New York City
Irwin, J. C. . . . . Albany, N. Y.

Jacoby, Henry S. . . . Ithaca, N. Y.
Johnson, Alexander. New York City
Johnston, J. P. . . . New York City

Kastl, A. E. . . . . Clinton, Mass.
Kaufman, G. . . . . New York City
Kelley, W. D. . . . . New York City
Kelly, Olaf M. . . . Brooklyn, N. Y.
Khuen, Richard, Jr. . Pencoyd, Pa.
Kimball, George A. Boston, Mass.
King, Paul S. . . . . New York City
King, Wallace, Jr. New York City

Knap, J. M.....New York City
Knowles, M.... Philadelphia, Pa.

La Chicotte, H. A..Brooklyn, N. Y.
Lee, W. B.....Hillburn, N. Y.
Leffingwell, F. D..New York City
Leisen, T. A ...Wilmington, Del.
Leonard, H. R...Lansdowne, Pa.
Leutzé, T. McC....Albany, N. Y.
Lewis, N. P.....Brooklyn, N. Y.
Liebmann, Alfred..New York City
Lindenthal, G.....New York City
Loomis, Horace...New York City
Low, George E....New York City
Lowinson, Oscar..New York City
Ludwig, Alfred ...New York City
Lundie, John.....New York City
Luster, W. H., Jr.Elizabeth, N. J.

Macdonald, Charles.New York City
MacGregor, R. A..New York City
Machen, H. B.....New York City
Maclay, W. W..Glens Falls, N. Y.
Macnab, G. T.....New York City
McCann, Thos. H.Hoboken, N. J.
McComb, C. O..Watertown, N. Y.
McKim, Alex. Rice.New York City
McMinn, T. J.....New York City
Magor, Basil.....New York City
Malukoff, A. J....New York City
Manley, Henry....Boston, Mass.
Martin, K. L.....Brooklyn, N. Y.
Martin, Wisner B..New York City
Mayer, Joseph....New York City
Mead, Chas. A.....Newark, N. J.
Melius, L. L.....Albany, N. Y.
Merriman, Mansfield
South Bethlehem, Pa.
Merriman, T.....New York City
Merryman, W. C..New York City
Metcalf, Leonard..Boston, Mass.
Millard, Curtiss..Springfield, Ill.
Miller, Hiram A...Clinton, Mass.
Miller, Rudolph P.New York City
Minor, Edw. E.New Haven, Conn.
Mixer, C. A...Rumford Falls, Me.
Meyer, Henry C...New York City
Modjeski, Ralph....Chicago, Ill.
Moisseiff, L. S....New York City
Moore, W. H..New Haven, Conn.
Morse, C. M.....Buffalo, N. Y.
Moses, P. R.....New York City
Moss, Robert E.Bloomfield, N. J.
Myers, C. H.....New York City
Myers, John H., Jr.New York City

Nelson, William...Laconia, N. H.
Nichols, C. H..New Haven, Conn.

Odell, F. S....Port Chester, N. Y.
Odell, R. I..Tomkins Cove, N. Y.
Olney, L. F.....Mahwah, N. J.
Opdyke, S. B., Jr. Philadelphia, Pa.
O'Rourke, John F.New York City
Osborn, Frank C..Cleveland, Ohio
Osgood, J. O.....New York City
Oxholm, T. S.
West New Brighton, N. Y.

Parker, A. McC...New York City
Parker, C. J....Watertown, N. Y.
Parker, M. S.....Sherman, Wyo.
Pegram, Geo. H...New York City
Peterson, P A....Montreal, Can.
Pierce, W. T.....Boston, Mass.
Piper, A. R.....Sing Sing, N. Y.
Pitts, Thos. D....New York City
Polk, W. A.....New York City
Pratt, Mason D.....Steelton, Pa.
Pratt, W. A....Philadelphia, Pa.
Prout, H. G.....New York City
Pruyn, F. L.....Brooklyn, N. Y.

Rafter, Geo. W..Rochester, N. Y.
Raymond, W. G.....Troy, N. Y.
Rice, Geo. S.....New York City
Richardson, T. F..Clinton, Mass.
Ricketts, Palmer C...Troy, N. Y.
Ridgway, Robert..New York City
Roberts, William.Waltham, Mass.
Rogge, J. C. L....New York City

Rosenthal, A...Mt. Vernon, N. Y.
Rotch, William....Boston, Mass.
Rowland, C. B...Brooklyn, N. Y.
Ryder, E. M. T..New Haven, Conn.

Savage, Albert C..New York City
Sax, P. M .....Philadelphia, Pa.
Scarborough, F.W.Richmond, Va.
Schmidt, Max E...New York City
Schneider, A.....New York City
Schneider, C. C.....Pencoyd, Pa.
Senior, F. S.....Holyoke, Mass.
Shaler, Ira A.....New York City
Simpson, George..New York City
Skinner, F. W.....New York City
Smith, J. Waldo..Paterson, N. J.
Smith, W. F.....New York City
Snow, J. P .....Boston, Mass.
Spencer, W. T..New Haven, Conn.
Spooner, A. N.....New York City
Starrett, M. G.....New York City
Stearns, Frederic P.Boston, Mass.
Steele, Henry M...Savannah, Ga
Steffens, W. F..New Haven, Conn.
Stern, E. W.....New York City
Stevens, Alexander.New York City
Stewart, J. H.....New York City
Stiger, J. S., Jr..Mendham, N. J.
Stoddard, Geo. C..New York City
Swain, Geo. F.....Boston, Mass.
Swindells, Jos. S.Mt. Kisco, N. Y.

Tainter, F. S.....Far Hills, N. J.
Tait, John G.....New York City
Taylor, Lucian A...Boston, Mass.
Taylor, W. J..Bound Brook, N. J.
Theban, J. G.....New York City
Thomson, G. H....New York City
Thomson, T. K....New York City
Thompson, S. C...New York City
Thornley, Julian..New York City
Tibbals, Geo. A..Brooklyn, N. Y.
Tingley, G. C...Providence, R. I.
Tilden, C. J.. .....Milton, Mass.
Tillson, Geo. W..Brooklyn, N. Y.
Tomkins, Calvin...New York City
Travell, Warren B..Orange, N. J.
Treadwell, Lee.Portsmouth, N. H.
Tribus, Louis L....New York City
Triest, W. G.....New York City
Trotter, Alfred W..New York City
Trout, Chas. E....New York City
Turner, D. L.....New York City
Turner, E. K.....Boston, Mass.
Twyman, A.....Pullman, Ill.

Ulrich, Daniel.....New York City
Upham, R. D.....New York City

Value, Beverly R...New York City
Van Winkle, E. B.New York City
Vickers, T. McE.Philadelphia, Pa.
Vielé, M. A..... Wyncote, Pa.
Vier, Henry.....New York City

Wadsworth, J.E.Middleton, Conn.
Wagner, J. C...Philadelphia, Pa.
Walker, C. I.....New York City
Wallace, John F....Chicago, Ill.
Wallace, J. H.....New York City
Ward, C. R.....New York City
Ware, R. W.....Plainfield, N. J.
Waterhouse, J....New York City
Watkins, F. W.White Plains, N.Y.
Webster, G. S..Philadelphia, Pa.
Webster, Wm.R..Philadelphia, Pa.
Whinery, S.....New York City
Whipple, G. C...Brooklyn, N. Y.
White, T. S.....Beaver Falls, Pa.
Whitted, L. R.....Norfolk, Va.
Whitney, Frank O.Boston, Mass.
Wiggin, E. W..New Haven, Conn.
Wiley, W. H.....New York City
Wilgus, W. J.....New York City
Wilkins, W. G.....Pittsburg, Pa.
Williams, G. S.....Ithaca, N. Y.
Wölfel, P. L.....Pencoyd, Pa.
Wright, J. Bodine.New York City

York, H. W.....New York City

ANNOUNCEMENTS.

The House of the Society is open from 9 A. M. to 10 P. M. every day, except Sundays, Fourth of July, Thanksgiving Day and Christmas Day.

MEETINGS.

Wednesday, March 6th, 1901.—8.30 P. M.—A regular business meeting will be held. Ballots for membership and ballots on the proposed amendment to the Constitution will be canvassed, and a paper, entitled "Flow in the Sewers of the North Metropolitan Sewerage System of Massachusetts," by Theodore Horton, Assoc. M. Am. Soc. C. E., will be presented.

This paper was printed in the *Proceedings* for January, 1901.

Wednesday, March 20th, 1901.—8.30 P. M.—At this meeting a paper, entitled "Heavy Railway Construction in Wyoming," by J. I. Boggs, Assoc. M. Am. Soc. C. E., will be presented.

This paper is printed in this number of *Proceedings*.

ANNUAL CONVENTION OF 1901

The Thirty-third Annual Convention of the Society will be held at Niagara Falls, N. Y., on Tuesday, Wednesday, Thursday and Friday, June 25th, 26th, 27th and 28th, 1901.

The rule adopted by the Board of Direction, February 28th, 1899, provides that no formal papers shall be set down for presentation to the Annual Convention, but in lieu thereof discussion be asked for on all papers which have been published in *Proceedings* during the six months immediately preceding.

It also provides that special subjects of engineering interest which may have been suggested to and approved by the Committee on Publications shall also be presented for discussion.

The success and professional value of this method may be seen by reference to the publications, and the following list of subjects chosen for discussion at the last two conventions is given for the information of members.

List of Subjects Presented for Discussion at the Annual Conventions of 1899 and 1900.

"Should the use of the method of Wheel-Concentrations be discontinued in determining the Stresses in Railroad Bridges?

"In view of present knowledge of the Effect of Repeated Applications of Load, should Fatigue Formulas be used in Bridge Design?

"(*a*) Should Stream Contamination by the Sewage of Cities be absolutely prohibited by law?

"(*b*) Should the Purification of the Sewage of Cities be compulsory, and is this feasible for Large Cities?

"(*c*) Is Filtration the coming solution of the Pure-Water Question for Cities?

"What is the Proper Friction Coefficient for use in the design of Riveted Steel Pipe?

"What are the economic conditions under which Electricity may be profitably substituted for Steam in the operation of Branch Railroad Lines, and what are the engineering requirements to be considered in such substitution?

"What is the present development of the so-called Telferage System for moving either Freight or Passengers? What are the conditions under which that System is preferable to movement by Rail, and what is its adaptability to still further application in competition with Rail Lines?

"Height of Buildings.

(1) What considerations should limit the height of buildings?

(2) Do recent developments in construction, sanitation, intercommunication and economy of administration, warrant the removal of all restrictions?

"Recent Practice in Rails.

The progressive increase in weight; the increase in hardness, particularly in carbon; the sections in most general use; the effect of changes in weight, composition and section.

"Filtration of Water for Public Use.

The several processes now used for the removal of objectionable matter; their comparative sanitary effect, cost and reliability."

The only way of ascertaining what special subjects will be of interest as topics for discussion at the Convention of 1901, is by appealing to the membership for suggestions. Such suggestions, forwarded to the Secretary, will be presented to the Publication Committee.

ADDITIONS TO LIBRARY.

Attention is called to the number of recent donations to the Library, as shown in the list on page 78. A summing up of the items there mentioned shows that in about one month there were added 99 bound and 96 unbound volumes, 117 pamphlets, 1 atlas, 107 maps and 18 specifications, a total of 438 accessions. It is gratifying to note that this number is much in excess of the ordinary rate of increase, and also that many of these accessions are directly traceable to the recent issue of the Catalogue of the Library, and have filled not a few gaps in incomplete sets of reports.

MONTHLY LIST OF RECENT ENGINEERING ARTICLES OF INTEREST.

(January 10th to February 13th, 1901.)

NOTE.—*This list is published for the purpose of placing before the members of the Society the titles of current engineering articles, which can be referred to in any available engineering library, or can be procured by addressing the publication directly, the address and price being given wherever possible.*

LIST OF PUBLICATIONS.

In the subjoined list of articles references are given by the number prefixed to each journal in this list.

(1) *Journal*, Assoc. Eng. Soc., 257 South Fourth St., Philadelphia, Pa., 30c.
(2) *Proceedings*, Eng. Club of Phila., 1122 Girard St., Philadelphia, Pa.
(3) *Journal*, Franklin Inst., Philadelphia, Pa., 50c.
(4) *Journal*, Western Soc. of Eng., Monadnock Block, Chicago, Ill.
(5) *Transactions*, Can. Soc. C. E., Montreal, Que., Can.
(6) *School of Mines Quarterly*, Columbia Univ., New York City, 50c.
(7) *Technology Quarterly*, Mass. Inst. Tech., Boston, Mass., 75c.
(8) *Stevens Institute Indicator*, Stevens Institute, Hoboken, N. J., 50c.
(9) *Engineering Magazine*, New York City, 30c.
(10) *Cassier's Magazine*, New York City, 25c.
(11) *Engineering* (London), W. H. Wiley, New York City, 35c.
(12) *The Engineer* (London), International News Co., New York City, 35c.
(13) *Engineering News*, New York City, 15c.
(14) *The Engineering Record*, New York City, 12c.
(15) *Railroad Gazette*, New York City, 10c.
(16) *Engineering and Mining Journal*, New York City, 15c.
(17) *Street Railway Journal*, New York City, 35c.
(18) *Railway and Engineering Review*, Chicago, Ill.
(19) *Scientific American Supplement*, New York City, 10c.
(20) *Iron Age*, New York City, 10c.
(21) *Railway Engineer*, London, England.
(22) *Iron and Coal Trades Review*, London, England.
(23) *Bulletin*, American Iron and Steel Assoc., Philadelphia, Pa.
(24) *American Gaslight Journal*, New York City, 10c.
(25) *American Engineer*, New York City, 20c.
(26) *Electrical Review*, London, England.
(27) *Electrical World and Electrical Engineer*, New York City, 10c.
(28) *Journal*, New England Water-Works Assoc., Boston, 75c.
(29) *Journal*, Society of Arts, London, England.
(30) *Annales des Travaux Publics de Belgique*, Brussels, Belgium.
(31) *Annales de l' Assoc. des Ing. Sortis des Ecôle Spéciales de Gand*, Brusseis, Belgium.
(32) *Memoires et Compte Rendu des Travaux*, Soc. Ing. Civ. de France, Paris, France.
(33) *Le Génie Civil*, Paris, France.
(34) *Portefeuille Economique des Machines*, Paris, France.
(35) *Nouvelles Annales de la Construction*, Paris, France.
(36) *La Revue Technique*, Paris, France.
(37) *Revue de Mecanique*, Paris, France.
(38) *Revue Générale des Chemins de Fer et des Tramways*, Paris, France.
(39) *Railway Master Mechanic*, Chicago, Ill.
(40) *Railway Age*, Chicago, Ill., 10c.
(41) *Modern Machinery*, Chicago, Ill., 10c.
(42) *Transactions*, Am. Inst. Elec. Eng., New York City, 50c.
(43) *Annales des Ponts et Chaussées*, Paris, France.
(44) *Journal*, Military Service Institution, Governor's Island, New York Harbor, 75c.
(45) *Mines and Minerals*, Scranton, Pa., 20c.
(46) *Scientific American*, New York City, 10c.
(47) *Mechanical Engineer*, Manchester, England.
(48) *Zeitschrift des Vereines Deutscher Ingenieure*, Berlin, Germany.
(49) *Zeitschrift für Bauwesen*, Berlin, Germany.
(50) *Stahl und Eisen*, Duesseldorf, Germany.
(51) *Deutsche Bauzeitung*, Berlin, Germany.
(52) *Rigasche Industrie-Zeitung*, Riga, Russia.
(53) *Zeitschrift des oesterreichischen Ingenieur und Architekten Vereines*, Vienna, Austria.
(54) *Den Tekniske Forenings Tidsskrift*, Copenhagen, Denmark.
(55) *Ingeniören*, Copenhagen, Denmark.
(56) *Teknisk Tidskrift*, Stockholm, Sweden.
(57) *Teknisk Ugeblad*, Christiania, Norway.
(58) *Proceedings*, Eng. Soc. W. Pa., 410 Penn Ave., Pittsburg, Pa., 50c.
(59) *Transactions*, Mining Institute of Scotland, London and Newcastle-upon-Tyne.
(61) *Proceedings*, Western Railway Club, 225 Dearborn St., Chicago, Ill., 25c.
(62) *American Manufacturer and Iron World*, 59 Ninth St., Pittsburg, Pa.
(63) *Minutes of Proceedings*, Inst. C. E., London, England.

NOTE.—There are no references made in this month's list to German and Swedish periodicals.

LIST OF ARTICLES.

Bridge.

Competitive Designs for the 95th Street Bascule Bridge over the Calumet River, Chicago.* (13) Jan. 10.
The Gokteik Viaduct, Burmah.* (14) Serial beginning Jan. 12, ending Jan. 26.
Converting a Fixed Bridge Span into a Swing Span.* (13) Jan. 17.
Steel-Concrete Piers for Clybourn Place Bascule Bridge, Chicago, Ill.* (13) Jan. 17.
The Charlestown Swing Bridge, Boston, Mass.* (13) Jan. 24.
Bascule Bridge over the Chicago River at Clybourn Place, Chicago.* (13) Jan. 31.
A Novel Suspension Bridge.* (14) Feb. 2.
A 103-Ton Plate Girder.* (14) Feb. 2.
The Charlestown Bridge, Boston.* (16) Feb. 9.
Note sur un Nouveau Type de Pont Suspendu Rigide. M. Gisclard. (43) 3e Trimestre. 1900.

Electrical.

Electrical Oscillations and Electric Waves. Dr. J. A. Fleming. (29) Serial beginning Dec. 28, ending Jan. 18.
A New Page-Printing Telegraph.* William B. Vansize. (42) Jan.
Air-Gap and Core Distribution. The Magnetic Flux and Its Effect upon the Regulation and Efficiency of Dynamo-Electric Machinery.* Part III. W. Elwell Goldsborough. (42) Jan.
Applications of Electric Power in Engineering Works.* Louis Bell. (9) Jan.
The Electric Distribution of Power in Workshops.* (3) Jan.
Beckenham Electricity Works.* (26) Jan. 4.
Electric Automobiles: A Retrospect and a Forecast. Henry F. Joel. (26) Jan. 4.
Electric Traction and Transmission in the New Century. Philip Dawson. (26) Jan. 4.
One Method of Dealing with the High Voltage Arc Lamp Trouble. J. G. Griffin. (26) Jan. 4.
Parallel Running for Central Stations. L. R. Lee. (26) Jan. 4.
Electric Plant of the Manhattan Elevated Railway.* (27) Serial beginning Jan. 5, ending Jan. 12.
The New Station of the New York Electric Vehicle Transportation Co.* R. A. Fliess. (27) Serial beginning Jan. 5, ending Jan. 12.
Ocean Cables. J. W. Marsh. (62) Jan. 10.
Nottingham Corporation Electric Lighting and Tramways.* (26) Jan. 11.
Report on Bipolar Machines Exhibited at the Paris Exhibition. R. Lloyd-Pearson. (26) Jan. 11.
Some Experiments on the Propagation of Hertzian Waves along a Wire and through the Air. Emile Guarini. (26) Serial beginning Jan. 11, ending Jan. 18.
The Case for Electric Power Distribution. W. B. Esson. (26) Serial beginning Jan. 11, ending Jan. 18.
The Exchange of the Atlanta, Ga., Standard Telephone Co.* (27) Jan. 12.
Economies in the Installation of Electric Tramway Plant.* W. H. Booth. (26) Jan. 18.
Peterborough Electricity Works.* (26) Jan. 18.
The Electric Travelling Crane.* (22) Jan. 18.
The Use of Aluminium as an Electrical Conductor, with New Observations upon the Durability of Aluminium and other Metals under Atmospheric Exposure. John B. C. Kershaw. (26) Jan. 18.
Electrical Equipment of High Power Guns.* Grahame H. Powell. (27) Jan. 19
Notes on Electrical Development and Experience in the Cripple Creek Mining District, Colorado. J. R. Cravath. (27) Jan. 19.
The Telegraphone.—A Magnetic Speech Recorder.* Valdemar Poulsen. (19) Jan. 19.
A Meter for Alternating Currents.* (26) Jan. 25.
The Accumulator as a Source of Economy in Electric Traction. W. H. Booth. (26) Jan. 25.
Southport Electricity Works and Tramways.* (26) Serial beginning Jan. 25, ending Feb. 1.
Dr. Pupin's Improvements in Long-Distance Telephony.* Herbert T. Wade. (19) Jan. 26.
Notes on Electric Light and Power Work at Butte, Mont.* J. R. Cravath. (27) Jan. 26.
75-Ton Four-Motor Electric Travelling Crane.* (47) Jan. 26.
The Washington, D. C., Electric Automobile Service.* (27) Jan. 26.
Aerial Electric Traction. Alton D. Adams. (10) Feb.
Electric Power Machinery in Iron and Steel Works.* Sydney F. Walker. (9) Feb.
Some Power Transmission Difficulties on High-Tension Electric Circuits.* I. R. Edmands. (10) Feb.
Northwick Electricity Works.* (26) Feb. 1.
The Development of Three-Phase Working in the Twentieth Century. Val. A. Fynn. (26) Feb. 1.
Acceleration of Electric Cars. Prof. George H. Morse. (17) Feb. 2.
The Dudley Corporation Central Station.* Ernest D. Phillip. (17) Feb. 2.
The Surface Contact System of the British Schuckert Electric Company.* (17) Feb. 2.
An Automatic Electric Cableway.* (13) Feb. 7.
Electric Illumination at the Beginning of the Twentieth Century. (27) Feb. 9.
Some Recent Tests of Magnetic Circuit Breakers.* Hugh A. Brown. (27) Feb. 9.

* Illustrated.

Electrical—(Continued).

The Automatic Telephone Exchange at New Bedford, Mass.* (27) Feb. 9.
The Evolution of the Stock Ticker.* Edward A. Calahan. (27) Feb. 9.
The Telephone Auto-Commutator.* (46) Feb. 9.
Tramway Électrique à Contacts Superficiels: Système Vedovelli et Priestley.* A. Delasalle. (36) Dec. 25.
Groupe Electrogène de 330 Kilowatts, Stork Frères et Cie.* Georges Henry. (33) Dec. 29.
Recherche du Poids d'Accumulateurs Électriques Nécessaires à la Propulsion d'un Vehicule. D. Dujon. (33) Jan. 25.
Groupe Électrogène de 1 200 Kilowatts, Erste Brünner Maschinenfabrik et Ganz et Cie.* Georges Henry. (33) Jan. 26.

Marine.

German Battleship, *Wittelsbach*.* (12) Dec. 28.
Life-Saving Appliances at the Paris Exhibition.* (12) Jan. 4.
The Use of Searchlights in Naval Warfare. (26) Jan. 4.
Shipbuilding and Marine Engineering in 1900. (11) Serial beginning Jan. 4, ending Feb. 1.
The French Submarine Boats. (12) Jan. 18.
Submarine Boats.* (12) Jan. 25.
The Coaling Stations of the United States Navy.* Waldon Fawcett. (62) Jan. 31.
The Hamburg-American Yacht *Prinzessin Victoria Luise*.* (46) Feb. 9.

Mechanical.

Steam Turbines—With Special Reference to the Westinghouse-Parsons Steam Turbine.* Francis Hodgkinson. (58) Nov.
Suggestions as to Fuel Economy.* Ira C. Hubbell. (61) Dec.
Holders at the Birmingham Gas-Works. (12) Serial beginning Dec. 7, ending Dec. 28.
Power-Gas and Large Gas Engines for Central Stations. Herbert A. Humphrey. (11) Serial beginning Dec. 21, ending Jan. 11.
Belleville Boiler-Making Machinery.* (12) Dec. 28.
The Causes of Rapid Wear and Tear of Fire-Boxes of Locomotives.* Robert Weatherburn. (12) Dec. 28.
A Study of Modern Foundry Practice.* Percy Longmuir. (9) Jan.
Dies for Drawing Wire—Their Manufacture and Use. William D. Pierson. (8) Jan.
Mechanism for Boring Elliptical Cylinders. Prof. C. W. MacCord. (8) Jan.
The Rites Shaft Governor. Charles Buerger and Charles Brackett. (8) Jan.
Elementary Graphics and Geometry of Thermodynamics. Robert H. Thurston. (3) Serial beginning Jan., ending Feb.
Direct Connected Steam Engines and Generators.* Frank C. Perkins. (20) Serial beginning Jan. 3, ending Jan. 10.
The Koerting Two-Cycle 350 Horse-Power Gas Engine.* (12) Jan. 4.
Pneumatic Tools and Appliances in Foundry Service.* W. H. Pressinger. (62) Jan. 10.
The Evans Multiphase Rotary Engine.* (20) Jan. 10.
Ropeway at the New Beachy Head Lighthouse.* (11) Jan. 11.
Marine Engine Shafting. J. D. McArthur. (47) Jan. 12.
The Working of Regenerator Furnaces. S. B. Chandley. (24) Jan. 14.
Briquetting—Its Progress and Commercial Advantages.* Henry S. Mould. (62) Jan. 17.
The Morgan Continuous Gas Producer.* (20) Jan. 17.
Crossley Gas Engines and Pierson Gas Producers at the Cassel Tramways. (11) Jan. 18.
Engines and Boilers of the *Inchdune* and *Inchmarlo*.* (11) Jan. 18.
The Sydenham Boiler Explosion. (12) Jan. 18
The Early Machine Tools of Henry Maudslay.* (11) Serial beginning Jan. 18, ending Feb. 1.
Gas Engine Built on Same Lines as Steam Engines.* (62) Jan. 24.
A New Riedler Air Compressor.* (14) Jan. 26.
Test of a Parsons Steam Turbine Driving a 1 000-Kilowatt Alternator.* (14) Jan. 26.
The Duff Gas Producer and Ammonia Recovery Plant.* (24) Jan. 28.
Belt Driving—Its History and Advantages.* John Tullis. (62) Jan. 31.
Improved Mill for Rolling Edges Together with Flat Shapers.* Albert G. Heinle. (62) Jan. 31.
The McCabe Improved Double Spindle Lathe.* (20) Jan. 31.
Auxiliary Steam and Water Appliances for Water-Tube Boilers.* B. H. Thwaite. (9) Feb.
British Vertical Steam Engines.* W. D. Wansbrough. (10) Feb.
Cranes at the Paris Exhibition.* Joseph Horner. (10) Feb.
Engine-Dynamo Construction.* (41) Feb.
High Speed Toothed Gearing.* James Christie. (2) Feb.
Interchangeable Gearing. Wilfred Lewis. (2) Feb.
Reducing the Cost of Machine Work. W. D. Forbes. (10) Feb.
The Colwell Rotary Engine, Reciprocating Engine and Condenser.* (10) Feb.
The Philadelphia City Hall Clock.* Warren S. Johnson, M. Am. Soc. M. E. (3) Feb.
Greater Economy of Gas Engines as Compared with Steam Engines. Herbert A. Humphrey. (62) Feb. 7.

* Illustrated.

Mechanical—(Continued).

Hydrostatic Tools in Railway Service.* George L. Gillon. (13) Feb. 7.
Regulating the Air Supply to Burners Consuming Mixed Coal and Water Gas. H. Leicester Greville. (24) Feb. 11.
Détermination de Certains Éléments des Moteurs à Vapeur en Vue de la Régulation. M. Delaporte. (37) Dec.
Essai sur la Théorie des Moteurs à Gaz. Jules Deschamps. (37) Dec.
La Théorie de la Machine a Vapeur et le Révélateur Donkin. Joseph Nadal. (37) Dec.
Les Moteurs autres que Ceux à Vapeur à l'Exposition de 1900. M. G. Leroux. (32) Dec.
Les Pompes Express Riedler à Commande Électrique.* M. Rouy. (37) Dec.
Les Types Nouveaux de Moteurs à Gaz de Haute Puissance en 1900.* Jules Deschamps. (33) Jan. 12.
Le Moteur Rotatif Hult.* Émile Dieudonné. (36) Jan. 25.
Gazogènes pour "Gaz à l'Eau."* Jules Deschamps. (33) Jan. 26.

Metallurgical.

Stamp Milling of Free Gold Ores.* Dana Harmon. (1) Dec.
The Effect of Annealing upon the Physical Properties and the Microstructure of a Low Carbon Steel.* Henry Fay and Stephen Badlam. (7) Dec.
On New Designs of Open-hearth Furnaces for the Manufacture of Ingot Iron.* R. M. Daelen and L. Pszezolka. (22) Jan. 11.
The Development of Iron and Steel Industries in Eastern Canada.* J. Steven Barrie. (22) Jan. 18.
The Chlorination of Gold Ores at Mount Morgan, Queensland. Ernest Willoughby Nardin. (16) Jan. 19.
The Works and Operations of the Bethiehem Steel Company.* (22) Jan. 25.
The Kernohan Steel Process.* R. B. Kernohan. (20) Jan. 31.
Cyaniding Stamp Mill Taillings in Western America.* Wm. Magenau. (45) Feb.
The Ore-Roasting Furnace.* (41) Feb.
Foundry Iron. Captain Henning. (20) Feb. 7.
The Hardening and Tempering Plant of J. H. Williams & Co.* (20) Feb. 7.

Military.

A New Quick-Firing Gun.* (46) Jan. 12.
The New Rifle of the German Army.* (19) Feb. 9.

Mining.

Self-Acting Incline for a Large Coal Output.* (22) Dec. 28.
Principles and Methods of Profitably Working the Mine. A. G. Charleton. (9) Jan.
The Practical Management of Mining Operations. John E. Hardman. (9) Jan.
A Proposed New Method to Raise Coal, etc., in Shafts. W. S. Gresley. (22) Jan. 4.
Ashley's Patent Mine Pump.* (47) Jan. 5.
Mining Machinery for the Philippines. (16) Jan. 19.
Copper Mining in the United States.* Waldon Fawcett. (62) Jan. 24.
Gold Dredging in California.* Thomas J. Barbour. (16) Jan. 26.
Gold Mining Developments in Georgia.* Prof. Wilber Colvin. (16) Jan. 26.
The Bora Creek Silver District, New South Wales.* (16) Jan. 26.
The New Texas Oil Fields.* (16) Jan. 26.
Gold Mining and Milling in Western Australia.* A. G. Charleton. (9) Feb.
Norton Coal Mines at Norton, Virginia.* (45) Feb.
Sulphur Mining in the North Pacific.* William H. Crawford, Jr. (10) Feb.
The Tong Colliery, Kaiping, North China. Thomas Webster. (45) Feb.
Metalliferous Mining in India. John W. Evans. (29) Feb. 1.
The Opening of Mines by Tunnels.* D. W. Brunton. (16) Feb. 2.
The Beaumont Oil Field, Texas.* William B. Phillips. (16) Feb. 9.

Miscellaneous.

George Westinghouse—Inventor, Organizer, and Director.* Walter M. McFarland. (9) Jan.
Lord Armstrong and the Elswick Works.* Benjamin Taylor. (9) Jan.
The Founders of the Krupp Establishments.* E. Schrödter. (9) Jan.
The Huge Enterprises Built up by Andrew Carnegie.* Charles M. Schwab. (9) Jan.
Nineteenth Century Engineering: Its Evolution, and Something of Its Beginnings in America. Edgar Marburg. (2) Feb.
Meteorological Instruments.* Prof. Hans Hartl. (19) Feb. 2.
The Design of Retaining Walls. Chas. Baillairgé, M. Can. Soc. C. E. (13) Feb. 7.

Municipal.

Municipal Improvements at Charleston, S. C. (13) Jan. 10.
The New Jersey State Road System. (14) Jan. 19.
Modern Brick Pavements. W. H. Tarrant. (14) Jan. 26.
Municipal Improvements at Atlanta, Ga.* (13) Jan. 31.
The Cost of Wagon Transportation and of the Maintenance of Earth Roads. (13) Jan. 31.
Engineering Work in the City of Havana.* (13) Feb. 7.
Paving Brick Specifications and Tests. (16) Feb. 9.
The Lighting of City Streets.* E. C. Jones. (24) Feb. 11.

* Illustrated.

Railroad.

American Practice in Block Signaling.* B. B. Adams. (15) Serial beginning Jan. 5, 1900, ending Dec. 28.
Box or Raised Patches and the Best Method of Applying Them to Fireboxes.* W. H. Graves. (61) Dec.
The Car Journal Bearing and Hot Boxes.* S. P. Bush. (61) Dec.
Notes on Rack Railways. C. O. Burge, M. Inst. C. E. (21) Jan.
Joint Chairs and Other Devices for Preventing Creep.* (21) Serial beginning Jan., ending Feb.
The Paris Exhibition—Express Engine with Auxiliary Driving Gear.* (12) Jan. 4.
A New Process for Finishing Rails at a Low Temperature; Edgar Thomson Steel Works, Pittsburg, Pa.* (13) Jan. 10.
The Cascade Tunnel; Great Northern Ry.* John F. Stevens, M. Am. Soc. C. E. (13) Jan. 10.
British and French Train Services in 1900. Charles Rous-Marten. (12) Jan. 11.
Corrugated Fire-Boxes for Locomotives. (15) Jan. 11.
Laycock's Brake for Railway Wagons.* (11) Jan. 11.
The Webb & Thompson Electric Switch and Signal Apparatus.* (15) Jan. 11.
Wide Fire-Box, Atlantic Type—Baltimore & Ohio Railroad.* (15) Jan. 11.
Section Third of the New York Rapid Transit Subway.* (14) Jan. 12.
Steam Ditching Car, Kansas City Southern Ry.* (18) Jan. 12.
The McKenna Process of Renewing Old Steel Rails.* (20) Jan. 17.
The Reconstruction of the Utah Central Railway.* W. P. Hardesty. (13) Jan. 17.
A New Method of Rating and Loading Engines in Freight Service. Thos. Tait. (15) Jan. 18.
Automatic Block Signals on the Fort Wayne.* (15) Jan. 18.
Derailments and Conclusions to be Drawn Therefrom. W. H. Elliott. (40) Jan. 18.
Renewing Old Steel Rails.* (40) Jan. 18.
Some Ten-Wheel Passenger Locomotives—Atchison, Topeka and Santa Fé.* (15) Jan. 18.
The L. M. Slack Steel Cars.* (15) Jan. 18.
Tramways in Large Cities. C. H. Wordingham. (26) Jan. 18.
Great Central Railway—Victoria Station, Nottingham.* (12) Serial beginning Jan. 18, ending Jan. 25.
American Car Ferries.* Waldon Fawcett. (46) Jan. 19.
The Rapid Transit Tunnel.* (46) Jan. 19.
Report of the Street Railway Commission to the City Council of Chicago. (17) Serial beginning Jan. 19, ending Jan. 26.
Curvature in Rails during the Rolling. A. W. Heinle. (62) Jan. 24.
Ten-Wheel Passenger Locomotives—Atchison, Topeka and Santa Fé, Class B-15.* (15) Jan. 25.
The Pennsylvania Railroad's Spring Plant at Altoona.* (15) Jan. 25.
Why Couplers Fail. (15) Jan. 25.
Frictional Effect of Railway Trains upon the Air. (18) Jan. 26.
German Express Locomotive with Auxiliary Driving Axle.* Frank C. Perkins. (46) Jan. 26.
Work on the New York Rapid Transit Railway.* (17) Jan. 26.
A New Manual Interlocking Machine.* (13) Jan. 31.
Air Brake Repairs: A Serious Matter Neglected. (39) Feb.
"Central Atlantic" Type Passenger Locomotive.* (25) Feb.
Composite Hopper Coal Cars 100 000 Pounds Capacity, Norfolk & Western Railway.* (25) Feb.
Compound "Atlantic" Type Passenger Locomotive, with Wide Firebox, Baltimore & Ohio Railroad.* (25) Feb.
Passenger Coach Sanitation. J. N. Hurty, M. D. (25) Feb.
The Handy Car.* (39) Feb.
The Locomotive-Truck Brake. (39) Feb.
The Question of the Cost of High-Speed Trains. Charles Rous-Marten. (9) Feb.
The Webb and Thompson Electric Point and Signal Apparatus.* (21) Feb.
The New Class I Central-Atlantic Type Locomotives—New York Central Railroad.* (15) Feb. 1.
A New Car Fender.* (17) Feb. 2.
Concrete Work on the East Boston Tunnel. (14) Feb. 2.
Inner Circle London Underground Railway.* (27) Feb. 2.
Murphy Third Rail in the Baltimore Belt Line Tunnel.* (18) Feb. 2.
Notable Points about the Spokane, Wash., Street Railway System.* (17) Feb. 2.
Notes on the Denver City Tramway.* (17) Feb. 2.
Proposed Equipment of the Inner Circle Railway, London.* (17) Feb. 2.
Signaling Trains through the St. Louis Tunnel.* (18) Feb. 2.
The Completion of the Albany and Hudson Third Rail Electric Railway.* (17) Feb. 2.
The "Handy" Freight Car.* (40) Feb. 1. (18) Feb. 2.
The Ohio River Electric Railway and Power Company.* (17) Feb. 2.
The Steepest Railways in the United States.* Waldon Fawcett. (46) Feb. 2.
Underground Railway Construction in London. W. H. Booth. (17) Feb. 2.
Unique Elevated-Underground Street Railway in Boston.* J. A. Stewart. (46) Feb. 2.
Heavy Filling on the Union Pacific.* (40) Feb. 8.

* Illustrated.

Railroad—(Continued).

Structural Steel Hopper-Bottom Car of the American Car & Foundry Company.* (15) Feb. 8.
The Accident at Offenbach, Germany. (15) Feb. 8.
Features of the Work of Grade Reduction, Union Pacific R. R.* (18) Feb. 9.
Repairs to Air Brakes on Box Cars.* H. H. Harvey. (18) Feb. 9.
Amélioration des Transports en Commun à Paris. Marcel Delmas. (32) Dec.
Appareil Avertisseur à Crocodile pour Voie Unique de la Compagnie du Nord.* M. Rouby. (38) Dec.
Compagnie des Chemins de Fer de l' Est: Notices Présentées par le Service de la Voie.* (38) Dec.
Pose de la Voie: Comparaison des Divers Modes de Travail Utilisés à Ce Jour. M. H. Seymat. (32) Dec.
Quelques Observations Relatives aux Locomotives à l' Exposition de 1900. (36) Dec. 25.
Locomotive à Grand Vitesse, Système Thuile, de la Société d' Étude des Trains Internationaux. Le Fleuter. (34) Jan.
Les Locomotives à l'Exposition de 1900: Locomotive Compound Articulée, Système A. Mallet.* F. Barbier. (33) Jan. 5.
Notice sur le Souterrain des Écharmaux, Ligne de Paray-le-Monial à Lozanne.* M. Pouthier. (43) 3e Trimestre, 1900.

Sanitary.

New Sewage Works in Paris. (12) Jan. 11.
Stream Pollution, Sewerage and Sewage Disposal in Connecticut. (13) Jan. 17.
Ventilating and Heating the Palace of the Crown Prince of Japan.* (14) Jan. 19.
Tunneling through Fine Sand (Sewer Construction).* (14) Jan. 26.
Garbage Disposal at Indianapolis, Ind. (13) Jan. 31.
Plumbing in the Astor Apartment House.* (14) Feb. 2.
Proportions in Combination Hot-Air and Hot-Water Heating. Prof. R. C. Carpenter. (14) Feb. 2.
A New Garbage Furnace at Atlanta, Ga. (13) Feb. 7.
The Sewerage System and Sewage Farm of the Melbourne and Metropolitan Board of Works. (13) Jan. 24.
The Disposal of Refuse in the Twentieth Century. G. Watson. (26) Jan. 25.
Central Station Heating. William H. Bryan. (14) Jan. 26.
Low-Pressure Steam Heating in France.* Gustave Debesson. (14) Jan. 26.

Structural.

The Granite City Plant of the National Enameling & Stamping Company.* (20) Jan. 10.
Fire-Resisting Wood. (12) Jan. 11.
The Internal Architecture of Steel.. Prof. J. O. Arnold. (12) Jan. 11.
The Works and Product of the Alpha Portland Cement Company. (15) Jan. 11.
The Agricultural Building at the Pan-American Exposition.* (14) Jan. 12.
The Building and Repairing of Tall Chimneys.* (46) Jan. 12.
Waterproofing the Basement of the Government Printing Office Building. (14) Jan. 12.
The United States Steel Company's New Plant.* (20) Jan. 17.
New Shops of the Wisconsin Central at Fond du Lac.* (18) Jan. 19.
Tests of Malleable Iron.* (40) Jan. 25.
A 360-Foot Single-Shell Chimney.* (14) Jan. 26.
Riddles Wrought in Iron and Steel. Paul Kreuzpointner. (10) Feb.
Underpinning High Masonry Structures.* (14) Feb. 2.
The Music Hall of the Pan-American Exposition.* (14) Feb. 9.

Water Supply.

Permanent Standards for Use in the Analysis of Water. Daniel D. Jackson. (7) Dec.
The Production of Distilled Water for Ice-Making Plants.* Hal Williams. (12) Dec. 28.
Testing Large Water Meters.* Lewis H. Nash. (8) Jan.
Artesian Boring at Gainsborough.* (11) Jan. 4.
Water Purification at Louisville.* (14) Serial beginning Jan. 5, ending Jan. 19.
The New Clear-Water Reservoir at Louisville, Ky.* (13) Jan. 10.
Hydraulic Power Plant, Montmorency Falls, Canada. Geo. W. Bowie. (12) Jan. 11.
Masonry Dams and Retaining Walls. Charles Baillairgé. (14) Jan. 12.
The Babylon Water Supply Plant.* (14) Jan. 12.
The Hartford Vitrified Water Conduit. W. E. Johnson. (14) Jan. 12.
The Hug Water Wheel.* (16) Jan. 12.
A Proposed New System of Mechanical Filtration for Louisville, Ky.* (13) Jan. 17.
Power Plant at the Snoqualmie Falls, U. S. A.* (12) Jan. 18.
Practical Notes on Water-Power for Electrical Purposes. R. F. Yorke. (26) Jan. 18.
Covers for Slow Sand Water Filters. Allen Hazen, M. Am. Soc. C. E. (13) Jan. 24.
Irrigation Farming in the Southwest.* D. Allen Willey. (46) Jan. 26.
A New Water Power Transmission Plant, Carrying Power from Apple River to St. Paul, U. S. A., at 25 000 volts.* Charles L. Fitch. (10) Feb.
Water Power for Electrical Purposes. E. Yorke. (47) Feb. 2.
Les Turbines de MM. Singrun Frères à l' Exposition de 1900.* (36) Jan. 10.

---

* Illustrated.

Water Supply—(Continued).

Adduction des Eaux du Loing et du Lunain.* F. J. Feugères. (33) Jan. 19.
Considérations Pratiques sur l'Épuration des Eaux Destinées á l'Alimentation des Générateurs.* J. Bertrand. (33) Jan. 19.
Travaux d' Extension du Service des Eaux de la Ville de Lyon.* Eugène Résal. (43) 3e Trimestre, 1900.

Waterways.

Central American Ship Canals.* (12) Serial beginning Oct. 26, ending Dec. 28.
Harbors and Waterways in the Nineteenth Century. (12) Jan. 4.
The Bates Hydraulic Dredger.* (11) Jan. 11.
Dredges for the New 40-Foot Channels of New York Harbor.* (46) Jan. 12.
The Water Supply of Lake Nicaragua: A Reply to Criticisms of the Hydrographer of the Nicaragua Canal Commission. Angelo Heilprin. (19) Jan. 12.
Improvements at the Mouth of the Yazoo River.* (18) Jan. 26.
American Isthmian Canals—Topical Discussion: The Topography and Hydrography of the Isthmian Region, James Christie; The Engineering Features of the Nicaragua Route, Edwin F. Smith; The Panama Route, Louis Y. Schermerhorn.* (2) Feb.
Russia's System of Internal Waterways.* Alexander Hume Ford. (9) Feb.
New York State Canal Situation. (15) Feb. 1.
The New Panama Canal Proposals. (11) Feb. 1.
The Development of Electric Traction on Canals.* (27) Feb. 2.
The Canals of Canada.* Waldon Fawcett. (46) Feb. 9.
Les Prescriptions de Service concernant les Travaux Hydrauliques en Prusse. L. Desmet. (30) Dec.
Nantes—Port Industriel.* A. Dufourny. (30) Dec.
Les Ports Tunisiens.* G. Leugny. (36) Jan. 10.
L'Alimentation Artificielle de la Neste: Aménagement du Lac du Caillaouas.* P. Frick. (33) Jan. 12.
Étude sur le Régime de la Marée dans les Estuaires et dans les Fleuves. M. Bourdelles. (43) 3e Trimestre, 1900.
Hydraulique des Cours d'Eau: Barrages à Encombrement et Barrage en Lit Evasé, sans Encombrement: Note. L. L. Vauthier. (43) 3e Trimestre, 1900.
Note sur les Calculs de Résistance d'une Carcasse de Porte d'Écluse. Gustave Cadart. (43) 3e Trimestre, 1900.

---

* Illustrated.

NEW BOOKS OF THE MONTH.

Unless otherwise specified, books in this list have been donated to the Library by the Publisher.

ENGINEERING STUDIES.

By Charles Evan Fowler, M. Am. Soc. C. E. Paper, 10½ x 7 ins., 2 v., illus. New York, The Engineering News Publishing Company, 1899-1900. 25 cents per vol.

This is a collection of photographic views of engineering works to which short descriptions and criticisms are appended. The contents are: Part I, American Stone Arches; Part II, Roman Stone Arches.

THE WINSLOW TABLES.

Diagrams for Calculating the Strength of Wood, Steel and Cast-Iron Beams and Columns. By Benjamin E. Winslow. Cloth, 9½ x 12 ins., 14 pp., 19 pl. New York, The Engineering News Publishing Company, 1900. $1.

The author states that his purpose in preparing this work is to furnish to engineers, architects and others interested in construction, a rapid and easy means of computing the sizes of beams and columns by the use of graphical tables. It is believed that this work includes all ordinary cases that are likely to occur in building construction. No attempt to deal with complicated engineering problems has been made.

STANDARD POLYPHASE APPARATUS AND SYSTEMS.

By Maurice A. Oudin, M. Am. Ins. E. E. Second Edition, Revised. Cloth, 8 x 5½ ins., 249 pp., illus. New York, D. Van Nostrand Company, 1900. $3.00.

In the preface, the author says that the development of polyphase apparatus and the applications of polyphase systems to the solution of engineering problems have been so rapid that there is no available literature on the subject which is at once practical and up to date. This book is an answer to the demand for information on the characteristics and uses of the various types of polyphase apparatus, and on the actual working of the several polyphase systems now sanctioned by the best practice. The headings of chapters are: Definitions of Alternating-Current Terms; Generators; Induction Motors; Synchronous Motors; Rotary Converters; Static Transformers; Station Equipment and General Apparatus; Two-Phase System; Three-Phase System; Monocyclic System; Choice of Frequency; Relative Weights of Copper for Various Systems; Calculation of Transmission Lines. There is an index of seven pages.

DYNAMO ELECTRIC MACHINERY;

Its Construction, Design and Operation. Direct Current Machines. By Samuel Sheldon, assisted by Howard Mason. Cloth, 8 x 5½ ins., 281 pp., illus. New York, D. Van Nostrand Company, 1900. $2.50 net.

This book is intended to be used primarily in connection with instruction on courses of electrical engineering in institutions for technical education. It is intended also for the general reader and to serve as a book of reference for engineers. The contents are: Electrical Laws and Facts; Magnetic Laws and Facts; Armatures; Field Magnets; Operation of Armatures; Efficiency of Operation; Constant Potential Dynamos; Constant Current Dynamos; Motors; Series Motors; Dynamotors; Motor-Generators, and Boosters; Management of Machines; The Design of Machines; Tests. There is an index of five pages.

FOWLER'S ELECTRICAL ENGINEERS' YEAR BOOK, 1901.

Compiled and Edited by Herbert Ade Clark and William H. Fowler. Leatherette, 6 x 4 ins., 423 pp., illus. Scientific Publishing

Company, Manchester, England. Red edges, post free, 1s. 9d.; Gilt edges, post free, 2s. 9d.

The Preface states that this book is the outcome of suggestions from numerous friends, who, while appreciating the section on electrical matters given in "Fowler's Mechanical Engineers' Pocket Book," were of the opinion that it did not fully meet the requirements of those exclusively devoted to the field of Electrical Engineering. The scope of the book is shown by the following headings: Electrical Units; Electrical Measurements and Testing; Regulations in Regard to Wiring; Measuring Instruments; The Electro Magnet; The Dynamo and the Motor; Electric Lighting; Circuit Breakers and Lightning Arresters; Alternate Electric Currents; Alternate Current Machines; Electric Traction; Electrical Power Transmission; Terrestrial Magnetism; Tables. There are sixty-four tables and an index of twenty-four pages.

ENGINE TESTS.

Embracing the Results of Over One Hundred Feed-Water Tests, and Other Investigations on Various Kinds of Steam Engines, Conducted by the Author. By Geo. H. Barrus, M. Am. Soc. M. E. Cloth, 9 x 6 ins., 339 pp., illus. New York, D. Van Nostrand Company, 1900. $4.00.

The author believes that the data here presented will prove of value to the engineering profession, to owners and intending purchasers of steam plants, and to any who are interested in the economical production of power. The contents are: Introduction; How the Feed-Water Tests were Conducted; Measurement of the Feed-Water; Indicating; General Method of Carrying on the Feed-Water Test; Leakage Tests of Valves and Pistons; Calibration of Instruments; Manner of Working up the Tests; Table of $\frac{13\,750}{\text{m. e. p.}}$; Feed-Water Tests of Simple Engines; Feed-Water Tests of Compound Engines; Feed-Water Tests of Triple Expansion Engines; Summary of Feed-Water Tests; Review of Feed-Water Tests; Valve Setting; Steam-Pipe Diagrams.

EXPERIMENTAL ENGINEERING.

A Treatise on Methods and Instruments Used in Testing and Experimenting with Engines, Boilers, and Auxiliary Machinery. By W W. F. Pullen, M. Inst. M. E. Cloth, 9 x 6 ins.. 654 pp., illus. Manchester, Eng. The Scientific Publishing Co. 15 shillings net.

An attempt has been made in this book to place before engineers and students a detailed account of some of the methods of carrying out experiments upon engines, boilers, and their auxiliary machinery, together with a description of the apparatus used. The contents are: Introduction, Mechanical Calculators; Measurement of Pressure and Temperature; Tables; Counters and Speed Indicators; Measurement of Power with the Dynamometer; Measurement of Power with the Indicator; Errors in Indicator Diagrams; Analysis of the Indicator Diagram; Adjustment of the Slide Valve; Pump Diagrams; Miscellaneous Diagrams; Measurement of the Quality of Steam; Measurement of Steam and Water; The Distribution of Energy on Its Way through the Engine; Boiler Testing; Gas Engine Experiments; Some Typical Experimental Installations, with the Results of some Typical Experiments. There is an index of fourteen pages.

THE CEMENT INDUSTRY.

Descriptions of Portland and Natural Cement Plants in the United States and Europe, with Notes on Materials and Processes in Portland Cement Manufacture. Reprinted from *The Engineering Record.* Cloth, 9 x 6 ins., 235 pp., illus. New York, *The Engineering Record,* 1900. $3 00.

The various chapters in this book were written individually by Messrs. S. B. Newberry, Frederick H. Lewis, Henry C. Meyer, Jr., Horace De R. Haight, Lathbury & Spackman, and Watson Valdenburgh, Jr.

The contents are: Portland Cement—Sketch of Materials and Process; The Portland Cement Plant of the Coplay Cement Company, Coplay, Pa.; The Plant of the Bronson Portland Cement Company, Bronson, Mich.; The Empire Portland Cement Plant, Warners, N. Y.; The Buckeye Portland Cement Plant, near Bellefontaine, Ohio; Western Portland Cement Company's Plant, Yankton, S. D.; New Works of the Coplay Cement Company, Coplay, Pa.; The Plant of the Michigan Portland Cement Company, Coldwater, Mich.; The Works of the Nazareth Portland Cement Company, Nazareth, Pa.; The Vulcanite Portland Ce-

ment Company's Works, Vulcanite, N. J.; New Works of the William Krause & Sons Cement Company, Martins Creek, Pa.; The Plant of the Lawrence Cement Company of Pennsylvania, Siegfried, Pa.; The Virginia Portland Cement Company's Works, Craigsville, Va.; The Whitehall Portland Cement Works, Cementon, Pa.; The Plant of the Lawrence Cement Company, Binnewater, N. Y.; The Plant of the New York and Rosendale Cement Company, Rondout, N. Y.; The Plant of the Milwaukee Cement Company, Milwaukee, Wis.; The Natural Cement Plant at Speeds, Ind.; The Plant of the Maryland Cement Company, Sparrows Point, Md.; The American Rotary Kiln Process for Portland Cement; Plants in England and Belgium; Plants in Germany; Plants in France.

A FIELD-MANUAL FOR RAILROAD ENGINEERS.

By J. C. Nagle, M. A., M. C. E. Second Edition, Revised. Morocco, 7 x 4 ins., 403 pp. New York, John Wiley & Sons, 1899. $3.00. (Donated by the Author.)

The author states that to insure ease of reference, an effort has been made in this work to secure a systematic arrangement of the subject-matter and uniformity of terms and notation. A knowledge of the elements of geometry and trigonometry has been assumed, and only in the derivation of a few formulas in connection with the theory of transition-curves will any higher mathematics be needed The book has been written so that it may be used as a text-book as well as for reference in the field. The headings of chapters are: Reconnoissance; Preliminary Surveys; Location; Transition-Curves; Frogs and Switches; Construction; Tables.

MODERN LOCOMOTIVES.

Illustrations, Specifications and Details of Typical American and European Steam and Electric Locomotives. One-Half Morocco, 16 x 11 ins., 532 pp., illus. *The Railroad Gazette*, New York, 1901. $7.00.

The preface states that this 1901 edition is the 1897 edition with the addition of specifications and more than 400 engravings, showing the progress made from 1897 up to the present time.

THE SEPARATE SYSTEM OF SEWERAGE;

Its Theory and Construction. By Cady Staley, M. Am. Soc. C. E., and Geo. S. Pierson, M. Am. Soc. C. E. Third Edition, Revised and Enlarged, with a Chapter on Sewage Disposal. Cloth, 8½ x 6½ ins., 324 pp., illus. New York, D. Van Nostrand Company, 1899. $3.00.

The preface to the first edition states that the object of this book is to explain what the Separate System is, what it is designed to do, and to give practical directions for designing and constructing sewers in accordance with that system. In this edition the greater part of the book has been rewritten, statistical tables revised, new matter added, and old matter eliminated. The headings of chapters are: Introduction; Water Carriage Systems; The Separate System; Plans; Quantity of Sewage; Laws of Flow in Sewers; Material and Accessories; Specifications and Contract; Construction; Flushing and Ventilating; House Drainage and Plumbing; Cost and Assessments; Combined Sewers; Sewage Disposal; Purification of Sewage by Application to the Soil.

ELEVATION AND STADIA TABLES

For Obtaining Differences of Altitude for all Angles and Distances; Horizontal Distances in Stadia Work, etc., with all Necessary Corrections, together with Hydraulic Tables, Giving Velocities for Various Channels and Slopes. By Arthur P. Davis, M. Am. Soc. C. E. Cloth, 8½ x 5 ins., 42 pp. $1.00. New York, John Wiley & Sons, 1901.

THE USE OF THE SLIDE RULE.

By F. A. Halsey. Boards, 6 x 4 ins., 84 pp., illus. New York, D. Van Nostrand Company, 1899. 50 cents.

The author states that this book is mainly a reprint of a series of articles which originally appeared in the *American Machinist*. It is to be taken as an instruction book rather than as a treatise. An understanding of the theory of logarithms is superfluous in acquiring a ready use of the slide rule, but it is necessary to have an understanding of their working property and a knowledge of the manner in which the rule is made to take the place of a table of logarithms.

HIGHER MATHEMATICS.

A Text Book for Classical and Engineering Colleges. Edited by Mansfield Merriman and Robert S. Woodward. Third Edition, Revised. Cloth, 9 x 6 ins., 576 pp. New York, John Wiley & Sons, 1900. $5.00. (Donated by G. C. Woollard.)

The aim of this work is to provide a suitable text-book for those students who, having finished the elementary course in calculus, desire to continue study in pure mathematics. The contents are: The Solution of Equations, by Mansfield Merriman; Determinants, by Laenas Gifford Weld; Projective Geometry, by George Bruce Halsted; Hyperbolic Functions, by James McMahon; Harmonic Functions, by William E. Byerly; Functions of a Complex Variable, by Thomas S. Fiske; Differential Equations, by W. Woolsey Johnson; Grassmann's Space Analysis, by Edward W. Hyde; Vector Analysis and Quaternions, by Alexander Macfarlane; Probability and Theory of Errors, by Robert S. Woodward; History of Modern Mathematics, by David Eugene Smith. There is an index of six pages.

RESERVOIRS

For Irrigation, Water-Power, and Domestic Water-Supply. With an Account of Various Types of Dams and the Methods and Plans of Their Construction. Together with a Discussion of the Available Water-Supply for Irrigation in Various Sections of Arid America; The Distribution, Application, and Use of Water; The Rainfall and Run-Off; The Evaporation from Reservoirs; The Effect of Silt upon Reservoirs, etc. By James Dix Schuyler, M. Am. Soc. C. E. Cloth, 10 x 7 ins., 414 pp., maps, illus. New York, John Wiley & Sons, 1901. $5.00.

In an Introduction the author says: "The purpose of this work is to familiarize the public with the details of construction, and the general features of interest appertaining to the principal reservoirs constructed or projected in the Western States and Territories which have come within the knowledge or the observation of the writer, describing in a popular way their characteristics, their water-supply, the results accomplished by them and the methods and materials employed in the construction of the dams which form them. The work does not pretend to be an exhaustive treatise on the subject of dam construction in Western America, nor does it assume to cover the field by an account of all the important dams which have been built." The contents are: Rock-Fill Dams; Hydraulic-Fill Dams; Masonry Dams; Earthern Dams; Natural Reservoirs; Projected Reservoirs; Appendix containing tables of reservoir areas, etc.

HYDRAULIC POWER ENGINEERING.

A Practical Manual on the Concentration and Transmission of Power by Hydraulic Machinery. By G. Croydon Marks, A. M. Inst. C. E. Cloth, 8 x 5½ ins., 360 pp., illus. New York, D. Van Nostrand Company, 1900. $3.50.

In this volume an attempt is made to give an outline discussion and description of the main points and principles requiring attention by engineers having the responsibility of designing or constructing works and appliances for the utilization of water for the transmission of power. The headings of chapters are: Principles of Hydraulics; The Observed Flow of Water: Hydraulic Pressures; Material; Test Load; Packings for Sliding Surfaces; Pipe Joints; Controlling Valves; Platform Lifts; Workshop and Foundry Cranes; Warehouse and Dock Cranes; Hydraulic Accumulators; Presses for Baling and Other Purposes; Sheet Metal Working and Forging Machinery; Hydraulic Riveters; Hand and Power Pumps; Steam Pumps; Turbines; Impulse Turbines; Reaction Turbines; Design of Turbines in Detail: Water Wheels; Hydraulic Engines; Recent Achievements; Appendix. There is an index of four pages.

DONATIONS TO THE LIBRARY.

FROM JAN. 10TH, 1901, TO FEB. 13TH, 1901.

Am. Inst. of Min. Engrs. 10 pam.
Assoc. of Ry. Supts. of Bridges and Buildings. 2 pam.
Boston Transit Comm. 1 bound vol.
Cal. Acad. of Sci. 1 pam.
Cal. State Min. Bureau. 1 vol.
Chandler, Charles F. 1 pam.
Colo. State Eng. 1 pam.
Cooper, Theodore. 1 bound vol., 4 vol., 8 specif.
Corthell, E. L. 1 pam.
Eng. News Pub. Co. 1 bound vol., 2 vol.
Engineering Record, The. 1 bound vol.
Eng. Soc. of the Univ. of Iowa. 1 vol.
Hartrick, E. M. 2 pam.
India Pub. Works Dept. 1 bound vol.
Inst. of Civ. Engrs. 2 vol.
Iron and Steel Inst. 1 bound vol.
Koninklijk Inst. van Ingenieurs. 1 bound vol.
McMinn, T. J. 6 bound vol., 7 vol.
Madras Pub. Works Dept. 1 bound vol.
Martin, Wisner B. 1 bound vol., 2 pam.
Mass. State Board of Health. 1 bound vol.
Maury, D. H. 2 pam.
Merchants' Assoc. of New York. 1 pam.
Middletown, N. Y. Board Water of Commrs. 3 pam.
Mont. Agricultural Exper. Station. 1 pam.
Nagle, J. C. 1 bound vol.
New England Cotton Mfrs. Assoc. 1 bound vol.
N. Y. State Univ. 1 vol.
Nichols, Charles H. 13 vol.
North-East Coast Inst. of Eng. and Shipbuilders. 1 bound vol.
North of England Inst. of Min. and Mech. Engrs. 1 pam.
Ontario-Provincial Board of Health. 4 bound vol.
Osborn, Frank C. 1 pam.
Osgood, Jos. O. 5 bound vol., 1 atlas.
Paine, Charles. 23 pam.
Penn. Univ. 1 vol.
Phil. Soc. of Glasgow. 1 vol.
Purdue Univ. 1 pam.
Queen's Univ. 3 pam.
Railroad Gazette, The. 1 bound vol.
R. Università Romana, Scuola d'Applicazione per gl'Ingegneri. 2 pam.
Schrenk, Hermann von. 2 pam.
Scientific Pub. Co. 2 bound vol.
Sears, Alfred F. 55 bound vol., 55 vol.
Smithsonian Inst. 1 bound vol.
Soc. for the Promotion of Eng. Education. 1 pam.
Thompson, Robt. A. 5 vol.
U. S. Bureau of Foreign Commerce. 1 pam.
U. S. Coast and Geodetic Surv. 1 bound vol., 1 vol.
U. S. Corps of Engrs. 36 pam., 10 specif.
U. S. Dept. of Agriculture. 1 pam.
U. S. Geological Surv. 1 bound vol., 14 pam., 107 maps.
U. S. Interior Dept. 1 vol.
U. S. Interstate Commerce Comm. 1 pam.
U. S. War Dept., Dept. of Havana, Cuba. 1 vol.
Van Nostrand Co., D. 6 bound vol.
Wallace, J. F. 1 pam.
Wiley, John & Sons. 2 bound vol.
Woollard, G. C. 1 bound vol.
Unknown Donors. 1 bound vol., pam.

MEMBERSHIP.

ADDITIONS.

MEMBERS.		Date of Membership.
Andersen, Christian,		
472 Park St., Portland, Ore		Jan. 2, 1901
Frew, Archibald Smith,		
Chf. Eng., Chillagoe Railway and Mines Co., Ltd., Mareeba, Queensland, Australia		Oct. 3, 1900
Guppy, Benjamin Wilder,	Jun.	June 19, 1891
Bridge Eng., Maine Central R. R., Portland, Me	Assoc. M.	Oct. 3, 1894
	M.	Feb. 6, 1901
Hall, Benjamin Mortimer,		
Eng., U. S. Geological Survey, 409 Temple Court, Atlanta, Ga		Feb. 6, 1901
Powell, Ambrose Vincent,		
Cons. Eng., American Ship Building Co., 1008 Chamber of Commerce, Chicago, Ill		Feb. 6, 1901
Richards, Albert Lennox,		
U. S. Asst. Eng., Rock Island, Ill		Jan. 2, 1901
Watt, David Alexander		
U. S. Asst. Eng., Bowling Green, Ky		Feb. 6, 1901
Wells, James Hollis,		
Civil Eng. for Clinton and Russell, 32 Nassau St., New York City		Feb. 5, 1901

ASSOCIATE MEMBERS.		
Allen, William Andrew,		
Const. Eng., Perth Amboy Plant, The Guggenheim Smelting Co., Perth Amboy, N. J		Feb. 6, 1901
Bell, Alfred Carroll,	Jun.	May 2, 1893
Contr. Eng., Wisconsin Bridge and Iron Co., 515 Guaranty Loan Bldg., Minneapolis, Minn.	Assoc. M.	Jan. 2, 1901
Hagar, Edward McKim,		
Man., Cement Dept., Illinois Steel Co., 1060 The Rookery, Chicago, Ill		Feb. 6, 1901
Hardison, Allen Crosby		
Caribou, Me		Feb. 6, 1901
Hawley, George Prince		
Care, Shawenegan Water and Power Co., Shawenegan Falls, Que., Canada		Feb. 6, 1901
Seltzer, Harry Kent,	Jun.	Feb. 4, 1896
Care, Midland Bridge Co., Box 385, Kansas City, Mo	Assoc. M.	Jan. 2, 1901

	Date of Membership.
SOPER, GEORGE ALBERT, 29 Broadway, New York City	Feb. 6, 1901
VOGLESON, JOHN ALBERT, 1700 Green St., Philadelphia, Pa	Jan. 2, 1901

ASSOCIATE.

MEYER, HENRY CODDINGTON, Jr., Editorial Staff, *The Engineering Record*, 100 William St., New York City	Jun. Jan. 3, 1893 Assoc. Dec. 28, 1900

JUNIORS.

BLACKWELL, PAUL ALEXANDER, 4427 Page Ave., St. Louis, Mo	Dec. 4, 1900
FORBES, HENRY DE BRETTON, Box 463, West Haven, Conn	Dec. 4, 1900
MACCRACKEN, GEORGE GERE, University Heights, New York City	Feb. 5, 1901
TYRRELL, WARREN AYRES, Asst. Eng., St. Louis Water Dept., 77 East May St., St. Louis, Mo.	Oct. 2, 1900
WELLER, FRANCIS REPETTI, Inspector, D. C. Eng. Dept. (Res., 408 C St., S. E.), Washington, D. C.	Feb. 5, 1901

RESIGNATIONS.

MEMBER.

	Date of Resignation.
SPROULE, WILLIAM JOHNSTON	Dec. 31, 1900

ASSOCIATE MEMBER.

HOUSTON, JOHN JAY LAFAYETTE	Dec. 31, 1900

JUNIOR.

PENFIELD, WALTER GRANT	Dec. 31, 1900

DEATHS.

BANNISTER, CHARLES KIMBALL ..... Elected Member May 3d, 1893; died Jan. 10th, 1901.

CONRO, ALBERT ..... Elected Fellow June 13th, 1883; died Jan. 10th, 1901.

LAWSON, WILLIAM BATEMAN ..... Elected Member Feb. 1st, 1893; died Jan. 27th, 1901.

Vol. XXVII. FEBRUARY, 1901. No. 2.

AMERICAN SOCIETY OF CIVIL ENGINEERS.

INSTITUTED 1852.

PAPERS AND DISCUSSIONS.

NOTE.—This Society is not responsible, as a body, for the facts and opinions advanced in any of its publications.

CONTENTS.

Paper to be presented: PAGE.

Heavy Railway Construction in Wyoming.
By J. I. BOGGS, Assoc. M. Am. Soc. C. E. 44

Discussions on Papers which have been presented:

Canals between the Lakes and New York.
By Messrs. RUDOLPH HERING, R. P. J. TUTEIN-NOLTHENIUS, GEORGE W. RAFTER, JOSEPH MAYER and GEORGE Y. WISNER. 60

The Kinzua Viaduct of the Erie Railroad Company.
By Messrs. H. A. LACHICOTTE, G. LINDENTHAL and F. H. CILLEY. 91

A Direct Method of Spacing Rivets and Finding the Position, Etc., of Stiffeners in Plate Girders.
By Messrs. H. A. LACHICOTTE, O. F. NICHOLS, F. D. RHODES, ERNST F. JONSON and E. SCHMITT. 106

The Adjustment of a Transit Survey as compared with that of a Compass Survey.
By Mr. GEORGE W. TUTTLE. 119

Vol. XXVII. FEBRUARY, 1901. No. 2

AMERICAN SOCIETY OF CIVIL ENGINEERS.

INSTITUTED 1852.

PAPERS AND DISCUSSION.

NOTE.—This Society is not responsible, as a body, for the facts and opinions advanced in any of its publications.

HEAVY RAILWAY CONSTRUCTION IN WYOMING

By J. I. BOGGS, Assoc. M. Am. Soc. C. E.

TO BE PRESENTED MARCH 20TH, 1901.

There are many in the East and South who have only faint ideas regarding the heavy construction being generally carried on by the great transcontinental railway lines in their efforts to reduce grades and straighten alignments; and these slight ideas are usually gathered from brief and incomplete notices appearing at irregular intervals in the daily and technical press.

Among others, the Union Pacific Railroad has shown remarkable activity in this direction. Its line has been shortened by many miles, and its grades reduced to a maximum of 0.82 of 1%, compensated 0.03 for each degree of curvature, the maximum curvature allowed being 4 degrees. On all new construction everything is being carried out to a perfect working model.

The highest summit on this line is at Sherman Hill, an elevation of 8 247 ft. above sea level, situated 33 miles west of Cheyenne, and 23 miles east of Laramie, Wyo. This has always been the *bête noir* of the transportation department. To overcome some of its difficulties a

NOTE.—These papers are issued before the date set for presentation and discussion. Correspondence is invited from those who cannot be present at the meeting, and may be sent by mail to the Secretary. Discussion, either oral or written, will be published in a subsequent number of *Proceedings*, and, when finally closed, the papers with discussion in full will be published in *Transactions*.

corps of engineers was placed in the field early in 1899 to locate a line from Laramie to Buford, the latter being a small station 7 miles east of Sherman. Several months were spent in locating the line, the final result exhibiting a large amount of curvature and an irregular profile. The summit, however, was lowered 240 ft., and the maximum grade was obtained by tunneling 3 400 ft. Not until the first part of April, 1900, did the company finally decide to construct, and appointed D. C. Dunlap, M. Am. Soc. C. E., as Resident Engineer in charge of the entire cut-off, with headquarters at Laramie. Under his able supervision the preliminary location was so altered as to reduce the length of tunnel to 1 800 instead of 3 400 ft. He also made other modifications, which reduced the cost materially.

On April 18th the contract to build the line was awarded to Kilpatrick Bros. & Collins, with a time limit of two years, and a bonus if finished in one year (which meant eight months). This firm afterward sublet the greater part of the work, reserving for itself that portion from Station 978, the west portal of the tunnel, to Station 1 098, these 120 stations being the most difficult part of the entire cut-off.

The writer had immediate charge of what is known as the Second Division, extending from Station 898 to Station 1 109, and his remarks will be confined to operations along these four miles, it being the purpose to present as concise a description as possible of the heaviest part of this very heavy work.

The curvature on this division was comparatively light, the maximum being 3°, with a total of 142° 03′ in angles, divided between four curves; but the grading was extraordinary, the quantities being as shown in Table No. 1.

TABLE No. 1.

Class of Work.	Section No.				Summary.
	18	19	20	21	
Embankment.....(cub. yds.)	81 545	.....	7 225	723 755	812 525
Earth excavation..... " "	3 860	27 215* / 27 300†	36 391	.....	94 766
Solid granite excavation..... " "	13 214	130 330* / 105 039†	52 569	11 105	312 257
1 800-ft. tunnel, solid granite. " "	.....	35 000	.....	.....	35 000
Totals.....(cub. yds.)	98 619	324 884	96 185	734 860	1 254 548

* West tunnel approach. † East tunnel approach.

Of the 723 755 cu. yds. of embankment on Section 21, 475 268 cu. yds. were in the fill at Dale Creek, between Stations 1 088 and 1 098. See Fig. 1.

The work was divided as follows:

Station 898 to 907, Mahoney Brothers; Subcontractors.
" 907 to 925, G. C. Smith; "
" 925 to 971, Mahoney Brothers; "
" 971 to 978, Beaumier Contracting Company; Subcontractors.
" 978 to 1 098, Kilpatrick Brothers & Collins; principals.
" 1 098 to 1 100, Rowan & Scott; Subcontractors.
" 1 100 to 1 109, Cushing & O'Keif; Subcontractors.

This being on the summit, there was no bridging to contend with, all water courses being taken care of by means of 24 and 30-in. cast-iron pipe, with the exception of Dale Creek, where three lines of 60-in. cast-iron pipe were laid in concrete. This pipe was in 12-ft. lengths, $2\frac{1}{2}$ ins. thick, and its weight averaged 1 270 lbs. per foot. Of this 60-in. pipe 936 ft. were placed at elevation 7 749, thus impounding 15 ft. of water for a pumping station, Dale Creek being the only constantly flowing stream, of any amount, on the division. The contractors were fortunate, however, in finding innumerable minor springs of very good water all over the country.

Snow storms were of daily occurrence and the ground was covered with snow from 1 to 6 ft. deep on April 21st, when Messrs. Kilpatrick Brothers & Collins began the erection of their camps. One camp was established opposite Station 1 005 and a second on Dale Creek. On April 30th the writer arrived, and found that for two days there had been a violent snow storm. The camps, however, were in good shape and the contractors were ready and anxious to begin work.

At the outset the contractors had to do much preliminary work; the building of a spur track two miles long for the ready delivery of material, from the main line of the Union Pacific Railroad; blacksmith and machine shops to be erected; electric light and compressed air plants, with their attendant wire and pipe lines, to be installed; a shaft for the tunnel to be started at once; nearly two miles of double-track 3-ft. gauge railway to be built; a pumping station to be placed on Dale Creek, with a pipe line extending to Station 960; besides many other important items, all demanding immediate and close attention, with not a day's time to lose, as the seasons in this altitude and lati-

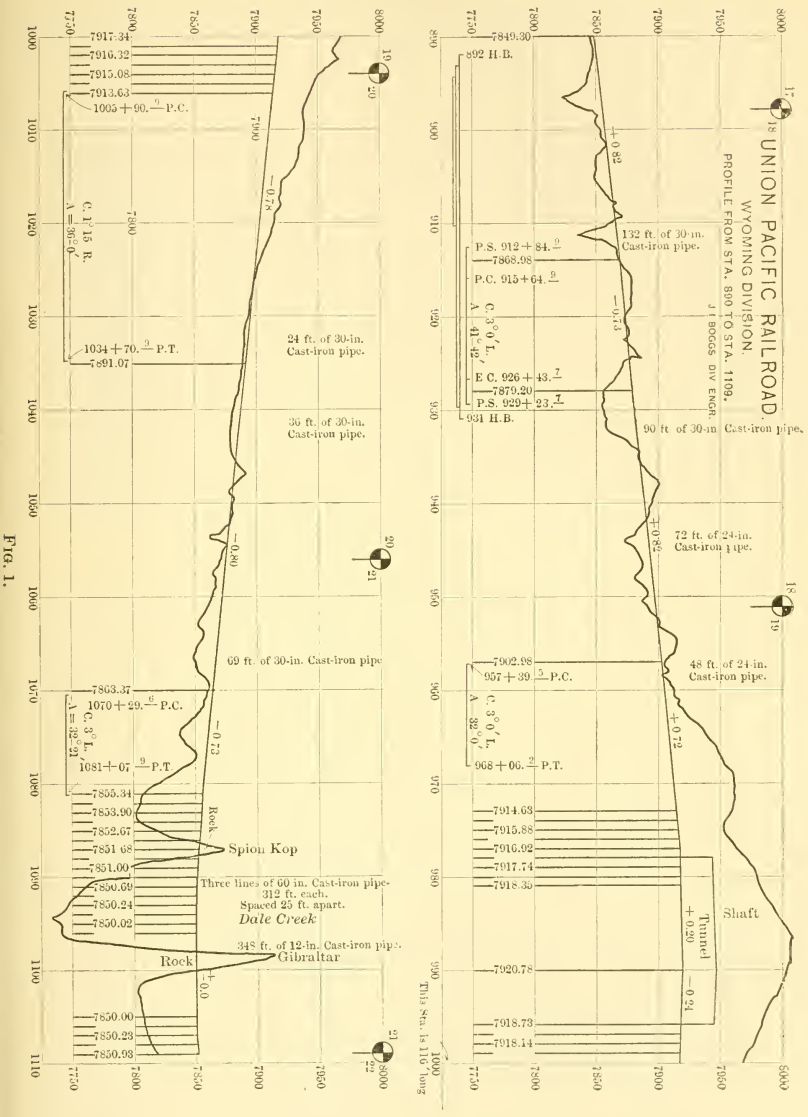

UNION PACIFIC RAILROAD.
WYOMING DIVISION.
PROFILE FROM STA. 890 TO STA. 1199.
J. T. BOGGS DIV. ENGR.
7849.30
892 H.B.
+0.92
132 ft. of 30-in. Cast-iron pipe.
P.S. 912+84.9
7868.98
P.C. 915+64.9
C. 3° 0′ L.
Δ 41° 42′
−0.13
E C. 926+43.7
7879.20
P.S. 929+23.7
931 H.B.
90 ft. of 30-in. Cast-iron pipe.
+0.82
72 ft. of 24-in. Cast-iron pipe.
7902.98
957+39.5 P.C.
C. 3° 0′ L.
Δ 32° 0′
968+06.2 P.T.
+0.72
48 ft. of 24-in. Cast-iron pipe.
7914.63
7915.88
7916.92
7917.74
7918.35
Tunnel
+0.20
−0.24
Shaft
7920.78
7918.73
7918.14
This Sta. is 110 long
7917.34
7916.32
7915.08
7913.63
1005+90.9 P.C.
C. 17° 15′ R.
Δ 36° 0′
−0.72
1034+70.9 P.T.
7891.07
24 ft. of 30-in. Cast-iron pipe.
36 ft. of 30-in. Cast-iron pipe.
−0.80
69 ft. of 30-in. Cast-iron pipe
7863.37
1070+29.6 P.C.
C. 8° 0′ L.
Δ 32° 21′
1081+07.9 P.T.
−0.72
7855.34
7853.90
7852.67
7851.68
7851.00
7850.69
7850.24
7850.02
Rock
Spion Kop
Three lines of 60 in. Cast-iron pipe 312 ft. each. Spaced 25 ft. apart.
Dale Creek
348 ft. of 12-in. Cast-iron pipe.
Gibraltar
Rock
+0.0
7850.00
7850.23
7850.93

Fig. 1.

tude are very short, the last snow storm having occurred on June 9th and the first of the next season on September 26th.

The first efforts at actual construction were directed toward getting a number of teams on the grade between Stations 1 030 and 1 069, and the writer's first duty was to cross-section between these points. On May 1st and 2d, in the midst of heavy squalls of snow, the engineer corps cross-sectioned the rock hill dubbed "Spionkop," between Stations 1 086 and 1 088, fifty rock men being started there at once.

In the morning of May 4th the east tunnel approach was cross-sectioned from Stations 996 to 1 023, and at 1 P. M. of the same day the excavation was commenced.

On the following day cross-sections were run from Stations 971 to 978, being part of the west tunnel approach, and work was started immediately after the stakes were driven, in fact, before all were in. At 5 P. M. of this day the first steam shovel arrived. On May 7th the foundations for the electric light and compressor plants were begun, and five laborers, with a foreman, began sinking a shaft for the tunnel at Station 984. On the same day Mahoney Brothers commenced the erection of their camps opposite Station 955. May 15th may be set as the date of the beginning of actual operations, for, although a number of teams had been working on the grade previous to this date, it was not until this day that the steam shovels were started, one being placed in a borrow pit opposite Station 1 060 and about 350 ft. to the south, a second beginning in the east tunnel approach at Station 1 004. At this time the double-track railway was completed as far as Station 1 070. Fig. 1, Plate I, is a general view of that portion of the work lying between Stations 1 070 and 1 098, "Spionkop" lying a little to the left of the center, with the "Rock of Gibraltar" beyond and to the left, the grade line being shown on the former by the cutting through its peak and on the latter by the working bench, while between the two lies Dale Creek and the famous fill of 475 000 cu. yds.

From this time on, machinery was rapidly put in place, until finally there were in operation eight steam shovels, and fifteen locomotives with trains of from ten to eighteen 3-yd. dump cars each. The machine drills were run by compressed air, and work was carried on both night and day, the works being lighted by electricity.

From May 15th to June 1st steam shovels and teams were engaged in building the embankment, from Stations 1 070 to 1 085, up as high

FIG. 1.—GENERAL VIEW OF HEAVIEST PART OF WORK; U. P. RY., IN WYOMING.

FIG. 2.—DALE CREEK FILL, U. P. RY., IN WYOMING.

as the lower level shown in Fig. 1, Plate I, this level striking "Spionkop," near the 7 825-ft. contour, or 27 ft. below grade. On June 4th a line following this contour as closely as possible was located around the hill for the 3-ft. gauge railway, the curves running from 40 to 70 degrees. This is partly shown in Figs. 1 and 2, Plate I. At Stations 2 + 71 and 4 + 73 on this narrow gauge line, split switch points were inserted, and about June 8th the active construction of the immense fill may be said to have been begun, by side-dumping and constantly throwing the track ahead. This side-dumping was continued until about July 19th, when, owing to the failure of the foundries to supply the 60-in. pipe promptly, the work on the west side of the creek had to be temporarily stopped. The contractors then commenced filling to the grade line west of "Spionkop," shown as the upper level in Fig. 1, Plate I. Prior to this, however, a line had been located and constructed on the 7 790 ft. contour, from a borrow pit on the east side of Dale Creek, around the base of "Gibraltar" to the south line of slope stakes. Here, one shovel and two trains were constantly pouring in material, in the quadrant of a circle whose radius was the distance between the opposite slope stakes; the track being occasionally lengthened by means of temporary trestles, one of which may be seen on the left in Fig. 2, Plate I. The location of a part of this line may also be seen in Fig. 1, Plate I. It was not until July 30th that the 60-in. pipes were in place, and work was resumed on the west side. By this time the bank west of Station 1 086 had been filled to grade, as shown in Fig. 1, Plate I, and it became necessary to remove the track from the south side of "Spionkop," disconnecting it at Station 2 + 71 and resorting to filling, in the quadrant of a circle, as was done on the east side. This continued until Station 1 093 was reached, when trestling was used, as shown in Fig. 2, Plate I. The height of the trestling, however, was reduced 20 ft. by having a number of teams build earth bases before its construction was commenced. On August 1st the narrow-gauge track was laid through the rock cut on the top of "Spionkop," and the first bent of temporary trestle for the upper and final lift was erected. Fig. 2, Plate I, shows the condition of the work on September 1st; "Spionkop" being on the extreme right, the first trestle to the left being to grade, the second 30 ft. below, and the one on the extreme left, coming from the shovel on the east side, 60 ft. below grade. December 1st saw this gigantic

bank of 475 000 cu. yds. completed. This fill is to take the place of a bridge on the main line 127 ft. high. The writer did not agree entirely with the foregoing method of construction, as it was productive of much expense, annoyance and delay. He is of the opinion that had a line been built around "Spionkop" on the 7 790-ft. contour with trestling from the first, it would have been found much more expeditious and less expensive; however, he was overruled in the matter at the time, but since then has had the poor satisfaction of having the contractors tell him that they regretted not having adopted his plan.

As stated, on May 7th, work was begun on a shaft for the tunnel at Station 984, and was continuously prosecuted, night and day, through the solid granite, until on June 13th a depth of 65 ft. was reached, 5 ft. below the springing line of the arch. Here the first difficulties and anxieties of the engineers in charge began, for it now became necessary to set grades and centers for the two headings; one working east, the other west. The writer had no suitable instruments, the best being an ordinary Gurley's plain transit, and a 20-in. level. He also had two 50-ft. metallic tape lines, and two 1-lb. plumb-bobs of cast iron, having points $\frac{1}{8}$-in. in diameter. Placing two 3 x 12-in. planks securely over the shaft, two nails were set on center and partially driven. A wire, fastened at each end to the nails, was then stretched across, and the two plumb-bobs were suspended therefrom. Two holes, one on each side, were then drilled 1 ft. above the crown, two wooden plugs were inserted, the plumbs were again dropped and two nails set. For elevation, two metallic tape lines were tied together and the elevation was measured in from a bench set at the edge of the shaft and checked by means of a wire measured to exact length over the level rod. Hoisting engines, gallows frame, and blacksmith shops were soon erected, and in a short time the center line was completely obstructed, so that when the headings were driven about 75 ft. on each side, and centers had to be reset, the first having been blown out, it became necessary to use an offset line. This, the writer disliked doing, owing to the poor character of the instruments at hand; however, it was imperative and he had no choice in the matter. At Station 992, east of the shaft, a right angle was turned and an offset line 60 ft. to the south established, and carefully checked in on a point at Station 982, to see that it was parallel. A point was then established opposite the shaft and a line run

PORTAL OF SHERMAN TUNNEL, U. P. RY., WYOMING.

across it at right angles to the direction of the headings. Two nails were again set, a wire stretched between and the two plumb-bobs dropped 9 ft. apart. A distance of 55½ ft. was carefully measured to the first and a point set beneath it in the floor of the shaft; the second was allowed to remain suspended as a foresight. Right angles were then turned and an offset line 4½ ft. south of the center was run along the floor of the headings in both directions. For the center, points in the roof were then set from this line, and plumbs suspended from them. For a check, as 3 ft. to the north would clear the obstructions east of the shaft, an offset line at that distance was run across it, and the two plumbs suspended with 6 ft. between them, a point being taken below one; the other remaining suspended, as before, for a sight. A 3-ft. offset line was run along the floor of both headings, and the points in the roof, previously set, were checked from this. These points checked fairly well, and were thereafter used to prolong the line when necessary.

The operations noted, while simple enough above ground, are very different beneath it, in a small comparatively dark hole, working by candle light, with the clatter of machine drills on all sides, gangs of "muckers" waiting, etc., especially when only very common field instruments are available. Unless the engineer in charge has a cool, clear-headed instrumentman he is likely to experience considerable trouble where the headings meet.

On one occasion, the instrumentman declared that nothing more could be done, as the cross-hairs had slackened so badly, from the surrounding moisture, that he could not set a point within ¼ in. Something more had to be done, as it was imperatively necessary to set a center ahead; so, in desperation, the writer picked up a couple of candles and placed the flame under the diaphragm of the cross-wires. This dried and straightened them up, and, with occasional applications of the candle flame, the work proceeded.

On July 6th the heading east from the west portal at Station 978, was started, and on August 23d, at Station 981 + 37, it met the heading being driven west from the shaft. The center line was then carefully checked up and was found to be exactly correct at Station 984, at the bottom of the shaft; while, where the two headings met, it was found that the line from the shaft was precisely 1 in. too far north, showing that a slight angle had been obtained in dropping the plumbs.

On July 26th the heading west from the east portal was started and continuously driven night and day until on December 8th, at Station 988 + 37, it met the heading driven east from the shaft. Work on the latter heading had been stopped on September 26th, after being driven 437 ft. At that time the force was put on the bench. The entire time occupied in driving the headings is shown in Table No. 2.

TABLE No. 2.

	Days.	Number of feet driven.	Average rate, in feet, per day.
West Portal	49	337	6.88
West Shaft	72	263	3.65
East Shaft	106	437	4.12
East Portal	139	763	5.49
Totals and average	366	1 800	4.92

Usually, six drills on three columns were worked in the headings, the cut being drilled 8 ft. and the round 10 ft. The most difficult and treacherous rock encountered was between the shaft and the west portal, and all this part will have to be timbered; while from the shaft to the east portal the material was very firm. The bench was taken out in two lifts, and the progress has been as shown in Table No. 3.

TABLE No. 3.

	Days.	Feet.	Average rate, in feet, per day.
West Portal	92	373	4.06
West Shaft	91	227	2.49
East Shaft	97	453	4.67
East Portal	51	180	3.53
Totals and average	331	1 233	3.73

Much time was lost between the completion of the heading and the starting of the bench at the west portal, as the entire heading had to be slowly and carefully timbered. As shown by the foregoing figures, 567 ft. of bench yet remain to be taken out, between the shaft and the east portal; this, at the present rate of progress, will require about 70 days' more time. It is hoped, however, that this estimate will be materially reduced.

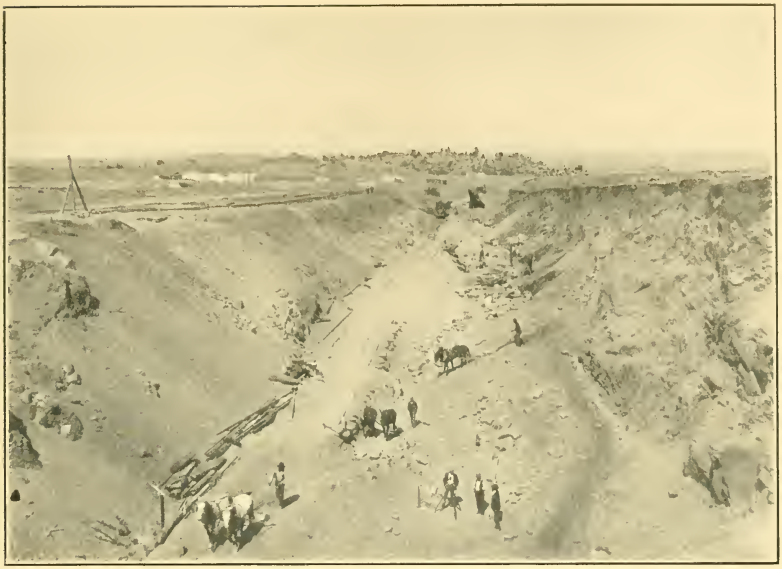


FIG. 1.—EAST APPROACH TO SHERMAN TUNNEL, LOOKING EAST.

FIG. 2.—EAST APPROACH TO SHERMAN TUNNEL, LOOKING WEST.

The forces employed in driving this tunnel, so far, reduced to a unit of one day, together with the wages paid, are shown in Table No. 4.

TABLE No. 4.

	Force, reduced to a unit of one day.	Wages paid.
Drillers	7 230	$3.25 per day
Drill helpers	8 710	2.25 "
Muckers	19 980	2.25 "
Foremen	1 236	125.00 per month
Total of all classes	37 156	

No water, of any amount, has been encountered. Plate II illustrates the method used in hoisting muck at the west end; it being then run out to the waste bank by cars. The frame-work on the right is the dumping frame for the skips. At the shaft the muck was hoisted in cages, in 1-yd. steel cars, which were run out on the waste bank and dumped. At the east portal, track was laid in as the work progressed, and the muck was run out through the east approach, and wasted.

Fig. 1, Plate III, is a view of the east approach, showing the condition of the work on July 23d. Fig. 2, Plate III, is another view of the same on August 25th. The tunnel heading can be seen near the center; on the right are the machine and blacksmith shops, the electric light and compressed air plant, known as "The Power House," while over the hill, and above the excavation, is the top of the smoke-stack of the hoisting engine and gallows frame at the shaft.

On May 22d Roman & Scott, with a force of eleven men, about all that could be worked to advantage, began excavating the deep rock cut at the hill dubbed "Gibraltar." This was a peak of solid granite, 70 ft. above the grade line at the highest point. Operations commenced by running a 3 × 4 ft. tunnel along the center line and at grade for 50 ft. An ell, 20 ft. long, was then drifted to the north, and charged with 8 750 lbs. of powder. Fig. 1, Plate IV is a view of the original hill with the tunnel entrance a little to the right of the center. This excavation was completed on November 1st.

On May 24th Cushing & O'Keif began on their 110 000-yd. embankment, 900 ft. long, and finished it on October 20th.

On June 16th the Beaumier Contracting Co. started on their 60 000-yd. excavation, 86% of which was solid rock, and finished it on December 31st.

On May 10th Mahoney Bros. started on their sub-contract, and will probably finish in February, 1901. Nearly all their excavations have been through the very hardest granite, and considerable difficulty has been encountered in moving it, on account of the immense amount of drilling necessary before the steam shovels could properly handle it. All the shallow excavations between Stations 907 and 925 consist of hard granite, and the roadbed being 47 ft. wide, on account of side tracks, made it very difficult; however, it was well handled. On July 31st Mr. Smith began by drilling holes 4½ and 5 ft. apart all over the surface, and on October 15th had finished the entire eighteen stations.

Out of 1 250 000 cu. yds. to be moved on the 4 miles, only 12 000 cu. yds., exclusive of the tunnel, remained on December 31st, 1900.

The specifications admitted of but two classifications, "Earth" and "Rock." All that could not be ploughed with a No. 1 breaking plow and six horses had to be classed as solid rock. To draw the line between the two was sometimes very difficult.

The writer does not claim anything extraordinary about this work, except the wonderfully short time in which an immense amount of railway grading can be accomplished with modern appliances and methods under difficult and discouraging conditions. One of the greatest annoyances to which the contractor is subjected in this section is the worthless, thriftless class of men he has to depend upon for labor.

Sections 18, 20 and 21 were entirely finished on December 31st, 1900, and final estimates were rendered. On Section 19 Mahoney Bros. still have about 12 000 cu. yds. to move and some sloping to do. Beaumier has to do some slope trimming, and not quite one-third of the bench in the tunnel has yet to be moved, while in the east approach about one-half the slopes have to be trimmed up and the cut ditched —the latter being difficult, owing to the frozen condition of the ground.

A profile of this division is shown in Fig. 1. From the start to the present time the forces, reduced to a unit of one day, have been as shown in Table No. 5.

FIG. 1.—"GIBRALTAR," U. P. RY., IN WYOMING.

FIG. 2.—ENGINEER'S HOUSE, U. P. RY., IN WYOMING.

TABLE No. 5.

Contractor.	G. C. Smith.	Mahoney Bros.	Beaumier Contracting Co.	Kilpatrick Bros. & Collins, and Wood Bros.	Roman & Scott.	Cushing & O'Keif.
Men.						
Foremen	230	1 046	704	6 854	203	240
Laborers	2 115	13 710	10 354	50 922	1 117	1 957
Drillers	385	1 850	527	7 625	307	.....
Machinemen	116	1 712	1 364	19 243	.....	.....
Trainmen	.....	1 488	.....	7 263	.....	.....
Totals	2 846	19 806	12 949	91 907	1 627	2 197
Teams.						
Scrapers	920	1 016	452	4 854	9	2 952
Carts	134	.....	.....	.....	216	.....
Plows	144	235	77	610	....	295
Wagons	.....	305	.....	520	.....	.....
Cars	.....	24	839	1 521	.....	107
Totals	1 198	1 580	1 368	7 505	225	3 354

G. C. Smith's Plant.

1 12-H.-P. portable boiler.

2 machine drills and a number of hand drills.

Mahoney Brothers' Plant.

1 55-ton Vulcan steam shovel; 60 H.-P., geared up to 100 H.-P.; capacity of dipper, 2 cu. yds.

1 80-ton Vulcan steam shovel; engines, 13 x 15-in.; single engine, 46 H.-P.; double engine, 96 H.-P.; geared up on gear and pinion four times and on hoisting chain twice; capacity of dipper, 3½ cu. yds.; boiler, 100 H.-P.

1 Barnhart, model "A," shovel. (The work done by this shovel was insignificant.)

1 10-ton locomotive; cylinders, 8 x 14 ins.

1 12-ton " " 9 x 14 ins.

50 3-yd. Western dump cars.

2 12-H.-P. stationary boilers.

1 10-H.-P. portable boiler.

6 machine drills.

1 complete derrick.

There were 267 steam-shovel days, and 384 locomotive days, with

3 421 cars in service. No record of the average car output was kept. The average length of haul was about 2 700 ft.

Beaumier Contracting Co.'s Plant.

1 45-ton Barnhart, model "A," steam shovel, of 50 H.-P., geared up to 75 H.-P.; capacity of dipper, 1½ cu. yds.
50 1-yd. dump cars, hauled by teams.
2 machine drills.
1 complete derrick, with 12-H.-P. stationary engine.
Shovels, picks, etc.

There were 131 steam-shovel days, with 3 206 cars in service. The average haul was 1 400 ft.

Plant of Cushing & O'Keif.

1 377 1-yd. cars.

Plant of Kilpatrick Brothers & Collins, and of Wood Brothers.

Machinery in Shops.

3 100-H.P. boilers.
1 air compressor, 250 H.-P.
1 " " 200 H.-P.
2 receivers (air usually carried at 6 atmospheres).
3 blacksmiths' forges.
1 steam hammer, 100 lbs., 2-ft. drop.
1 Am. Tool Co. lathe, 36-in. swing, 8-ft. centers.
1 " " " 24-in. " 16-ft. "
1 planer, 14-ft. bed, 3 ft. under head.
2 drill presses, 5½ ft. and 3 ft.
1 bolt cutter, ½ in. to 1½ in.
1 Rice's automatic engine, 9 x 15 ins.
1 30-H.-P. high-speed engine.
1 30-H.-P. Atlas engine.
1 72-H.-P. dynamo, 250 volts.
1 50-H.-P. dynamo, 125 volts.
1 40-H.-P. boiler.

Machinery at Shaft.

1 Lidgerwood double hoisting engine, cylinders 10 x 16 ins., with double drum.
1 75-H.-P. boiler.
2 steel shaft cages, 7 500 lbs. each.
8 1-yd. steel cars.
1 blacksmith's forge.

Machinery at West Portal.

1 pair of hoisting engines, 7 x 9 ins.
1 40-H.-P. boiler.
1 blacksmith's forge.
1 complete derrick.

Steam Shovels.

1 90-ton Barnhart, Model "K"; boiler, 100 H.-P.; engines, 13 x 15 ins.; single 46 H.-P.; double, 92 H.-P.; geared up on gear and pinion four times and on hoisting chain twice; capacity of dipper, 3½ cu. yds.
1 60-ton Barnhart, Model "G"; boiler, 75 H.-P.; engines, 12 x 14 ins.; single, 30 H.-P.; double, 60 H.-P.; geared up on gear and pinion four times and on hoisting chain twice; capacity of dipper, 2½ cu. yds.
1 70-ton Bucyrus, No. 350; boiler, 75 H.-P.; engines, 10 x 16 ins. single, 35 H.-P.; double, 70 H.-P.; geared up on gear and pinion five times and on hoisting chain twice; capacity of dipper, 2½ cu. yds.
1 50-ton Bucyrus, No. 157; boiler, 70 H.-P.; engines, 10 x 14 ins.; single, 30 H.-P.; double, 60 H.-P.; geared up on gear and pinion five times and on hoisting chain twice; capacity of dipper, 2½ cu. yds.

On the Works, Generally.

7 12-ton Porter engines; cylinders, 9 x 14 ins.
1 10- " " " 8 x 11 "
1 10- " Porter & Bell engine; cylinders, 10 x 12 ins.
2 15- " Baldwin engines; cylinders, 10 x 16 ins., 6-wheel connected.
1 15- " " " 10 x 15 " " "

4 Fairbank's M. & Co. pumps, 6 x 4 x 6 ins.
250 3-yd Western dump cars.
50 1-yd. dump cars.
25 machine drills.
3 water tanks; 8 000 galls. each.
5 wagon tanks.
$2\frac{1}{2}$ miles of 3-in. iron pipe.
3 600 ft. of 4-in. iron pipe.
2 000 " $2\frac{1}{2}$-in. "
300 " $1\frac{1}{2}$-in. "
1 000 " 1-in. "

Also a number of shovels, picks, lanterns, cables, etc., etc.

The actual shovel output is shown in Table No. 6, together with the average haul, etc.

TABLE No. 6.

Shovel.	Cars.	Average haul.
Bucyrus, No. 157	14 094	2 000 ft.
Bucyrus, No. 350	61 436	8 000 "
Barnhart, Model "K"	65 791	9 500 "
Barnhart, Model "G"	58 221	1 600 "
Total	199 542	.....

There were 472 steam-shovel days and 1 479 locomotive days, with 17 898 cars in service.

The quantity of powder used by Kilpatrick Brothers & Collins on their portion of the work, between Stations 978 and 1 098, was as follows:

Gelatine	106 700 lbs.
Dynamite (50%)	49 350 "
Judson powder	10 600 "
Black powder	139 250 "
Total	305 900 "

For skilled labor the rate was generally $3 per day; for unskilled labor $2 per day, and for foremen $100 per month.

There have been few accidents, considering the magnitude of the

work. Three men have lost their lives, and less than a dozen have been injured, only two of these seriously.

Too much praise cannot be given to the contractors, Messrs. Kilpatrick Brothers & Collins, and Wood Brothers, for the vigorous manner in which they carried out the work.

Fig. 2, Plate IV, exhibits the style of houses built by the Union Pacific Railroad Company for the use of the Division Engineers and their parties. On the right of the main building is a large room, accommodating eight men with comfort; in the center is the living room and kitchen; on the left is the engineer's office and bedroom. The ell consists of two rooms for the accommodation of the engineer's family. The house was double-walled, with tar paper between, and closely ceiled.

No trouble or expense was spared by Mr. Dunlap in making the men under him comfortable; the house was well and completely furnished by the company, and there was a plentiful fuel supply, which is greatly needed in that severe climate. The house was lighted by electricity from the "Power House."

The writer desires to return thanks to his instrumentman, Mr. A. J. Wharf, for his careful, patient and painstaking work, which made it possible to accomplish such good results.

It may seem that this paper is premature, because the work is not yet finished. The writer regrets this, and offers in excuse the fact that the present seemed to be the only time which he could devote to its preparation.

Vol. XXVII. FEBRUARY, 1901. No. 2.

AMERICAN SOCIETY OF CIVIL ENGINEERS.

INSTITUTED 1852.

PAPERS AND DISCUSSIONS.

NOTE.—This Society is not responsible, as a body, for the facts and opinions advanced in any of its publications.

CANALS FROM THE LAKES TO NEW YORK.

Discussion.*

By Messrs. RUDOLPH HERING, GEO. W. RAFTER, R. P. J. TUTEIN-NOLTHENIUS, JOSEPH MAYER and GEORGE Y. WISNER.

Mr. Hering.

RUDOLPH HERING, M. Am. Soc. C. E. (by letter).—The relative merits of a ship canal and a barge canal from Lake Erie to the Hudson River have evidently been insufficiently demonstrated to enable a decision to be reached at present—a strong array of facts and talented arguments still appearing on both sides.

One might draw the inference that therefore a fair balance exists between the two projects, and that the total advantages are nearly equal, although not identical. It seems more probable, however, that there is as yet insufficient knowledge regarding some of the facts which must control the enterprise, and that considerable time may yet elapse before they are obtained.

Regarding the cost of construction there should not be much difference of opinion, if a definite plan is once established. The probable revenue, on the other hand, is a speculative sum, and neither the authors nor some of the discussors seem to have supported their assumptions with sufficient evidence to satisfy either the capitalist or the legislator. It seems to the writer that here there is room for more facts.

*Continued from December, 1900, *Proceedings*. See October, 1900, *Proceedings*, for papers on this subject by Messrs. Joseph Mayer and George Y. Wisner, Members, Am. Soc. C. E.

Leading up to the revenue is the use that will be made of the canal; and this depends partly upon the tolls to be exacted and partly upon the speed which can be obtained. Mr. Hering.

In the Kaiser Wilhelm Canal, vessels capable of making 16 knots per hour in open sea, with a midship section equal to one-third of the canal, and using the same power, made only between 5 and 6 knots per hour. In the Suez Canal, the *Austral*, with 43 revolutions of the screw, and capable of making a speed of 11 knots in open sea, made only 5 knots per hour. We, therefore, cannot rely on much higher speeds than these for large vessels, even in a ship canal such as the one proposed, which fact, in addition to those mentioned, affects the probable revenue.

The suggestion that steamers from the Upper Lakes would go to Europe *via* the St. Lawrence River, that is, through Canada, instead of *via* New York City, does not seem to the writer to argue against the ship canal, any more than a statement that the Michigan Central Railroad, passing from Buffalo to Chicago through Canada, would injure our national interests. Why should not a United States steamer, as well as a railroad train, pass through Canada? The section from Lake Ontario to New York would have to depend largely on the business intended for the Atlantic Coast. It may not be improbable that even the Gulf Coast could be supplied more economically by such a ship canal from the Lakes, and without transfer, than by the Mississippi Valley or by rail.

One reason, not already suggested, why private capital prefers investments in railroads to long canals, may be the fact that the capital required is very much larger. The investor is not much interested in the other fact, that the running expenses are much larger for railroads than for canals.

George W. Rafter, M. Am. Soc. C. E. by (letter).—Mr. Hinds writes approvingly of the continuously-descending canal from Buffalo to the Mohawk Valley, but it seems clear to the writer that, had he possessed more extensive information as to the difficulties of the route, this project would not have received his approval. In the end it will pass into the realm of impractical projects, which have only gained importance so long as the conditions were unknown. Mr. Rafter.

The writer was Consulting Engineer to the Canal Committee appointed by Governor Roosevelt. This Committee began by assuming that a continuously-descending canal was in every way a meritorious project, and hence directed, first of all, that it be examined in detail. It soon appeared that there were two routes, as follows: (1) A southern route, which passed to the south of Seneca River; (2) A northern route, passing to the north of that stream; and finally, a route which was not continuously-descending, *via* Seneca River itself. The southern route is the one suggested by Elnathan Sweet, M. Am. Soc. C. E. On

Mr. Rafter. very casual examination it appeared certain that this route involved very great difficulties for the entire distance from Newark (the proposed point of diversion) to near Syracuse, a distance of over 50 miles. The country is sand and gravel, with absolutely no stone, while at Syracuse there is a very heavy cut to be made. The Montezuma marsh is also encountered. Even for a 12-ft. canal the estimate for 58 miles was $29 000 000.

The southern route having turned out to be exceedingly expensive, a route to the north of Seneca River was then examined. The region here is of the same general character as to the south, except that the Montezuma marsh is avoided. There would be a crossing of Seneca River, a short distance east of Baldwinsville, which would require a very deep and heavy foundation for an aqueduct. The estimated cost of this route was $22 000 000 for about 58 miles.

The high-level, continuously-descending canal, by either the northern or southern routes, having thus developed very great difficulties, the writer then proposed the Seneca River route, which in every particular answers the requirements. Space will not be taken to describe this route in detail. The State Engineer informs the writer that his report thereon will be published in the Annual Report for 1900, which will make it available to anyone interested. Attention, however, may be directed to the maps which accompany the report. They were compiled from the field sheets of the U. S. Geological Survey at a scale of $\frac{1}{45\,000}$, and exhibit, it is believed, every necessary feature.

In addition to these three routes, an extension of the Syracuse level, east and west, was examined. The total distance, carefully gone over, was fully 300 miles. Approximate profiles were plotted for the several routes, and it is believed that there are no longer any unknown problems in the country from Newark to Syracuse, all of which is set forth in the report in considerable detail.

The practical conclusion to be drawn from this examination is that for a canal of the dimensions of the proposed deep waterway, the project, while not absolutely impossible, becomes substantially impractical. There are ways by which the same result may be obtained so much cheaper as to render it exceedingly improbable that a canal will ever be carried out by the continuously-descending route.

The locations of the several canal lines are made in such a manner as to bury the canal below the present surface, as far as possible, thus insuring freedom from embankment breaks. By way of further insurance, embankments over 10 ft. in height have been designed with masonry core walls, in accordance with the best recent practice. Under 10 ft. in height they have been designed merely with puddle walls. In water-tight materials, the puddle walls have been omitted.

Some question may arise as to the necessity for masonry core walls in canal embankments. In the writer's opinion, they are necessary, in such

large construction as is here proposed, as an absolute guarantee against breaks. A main line of transportation—a national highway—should not be subject to the possibility of broken embankments, with consequent delay of all traffic for 5 to 15 days. Mr. Rafter.

In order to show the experience under this head on the New York State Canals, Table No. 1 is submitted. This table includes all breaks reported by the Superintendent of Public Works from 1888 to 1898, inclusive, except for the year 1890, for which the data are not at hand.

TABLE No. 1.

Year.	Number of breaks reported.	Total detention, in days.	Percentage of a navigation season of 210 days.
1888	7	24	11.4
1889	4	14	6.5
1891	5	28	13.3
1892	5	7	3.3
1893	4	21	10.0
1894	6	10	4.8
1895	3	12	5.7
1896	2	6	2.9
1897	4	55	26.2
1898	11	74	35.2
Totals for 10 years	51	251	Average 12.0

The most serious break was that at the Adams Basin on the Erie Canal, in 1888, which stopped all navigation between Rochester and Buffalo for 12 days.

In 1891, two breaks on the Erie Canal occurred at the same time—one at an aqueduct and the other a defective embankment—which required 10½ and 9 days, respectively, to repair.

In 1893, a break of an embankment of the Glens Falls feeder required 11 days to repair.

In 1896, there were two breaks, and the total detention was only 6 days. One of these breaks was on the Black River Canal and the other on the Eastern Division of the Erie Canal.

In 1897, a serious break occurred on the Forestport feeder, which required 38 days for repairs. These figures are included in the total detention for that year.

In 1898, the total number of breaks was eleven, causing a total detention of 74 days, of which 16 are included in the repairs of a break in the Forestport feeder embankment at the same point as the break in 1897. With the exception of two breaks on the Champlain Canal, all the other breaks of 1898 were on the Erie Canal, the total detention from the Erie Canal breaks being 53½ days. The Erie Canal breaks were all through embankments, and, with one exception, were at points where culverts pass under. The detail of the foregoing breaks

Mr. Rafter.

may be obtained from the Annual Reports of the Superintendent of Public Works.

The statements given in the Superintendent's reports show that muskrats, by their burrowing, frequently cause embankment breaks. So far as known, masonry core walls are the only effectual remedy for this difficulty.

Breaks at and about the ends of locks form also a considerable proportion of the whole. The carrying of a concrete core wall into the embankments at the lower ends of locks would correct this difficulty.

A strong argument for the additional expenditure required to construct core walls in embankments may be drawn from the foregoing tabulation of the number of breaks, etc., from 1888 to 1898, inclusive. Even when cases like the Forestport feeder breaks, in 1897 and 1898, are deducted, the clear indication is that embankments without core walls are too dangerous for a great through transportation line such as is here proposed. Such a line, to be satisfactory to all the interests using it, must be so constructed as to be beyond the mutations of ordinary accidents. It would be difficult to make any time-limit contracts with the possibility of delays of 5 to 20 days caused by breaks.

In considering the foregoing question on its merits it must be further remembered that doubling the quantity of water in the canal prism makes the destructive effect of breaks at least fourfold as great as at present. The cost of repairs and damages would, therefore, become very large.*

Taking the foregoing into account, the writer's view is that new work should include estimates for masonry core walls in all embankments over 10 ft. in height.

Mr. Tutein-Nolthenius.

R. P. J. Tutein-Nolthenius, M. Am. Soc. C. E. (by letter).—The writer agrees with Mr. North that all sea commerce is not carried in ocean leviathans, but that fair profits may be made by smaller vessels. Freighters of the same size as the steamers which run regularly from Cöln and Duisburg, on the Rhine, to different ports on the North Sea, and are said to pay a dividend of 13%, would probably carry freight advantageously from Duluth to New York if a canal of proper dimensions existed between the Lakes and the Hudson.

As will be seen by Table No. 1, which gives the dimensions of all the marine steamers now running on the Rhine, different companies build ships of different lengths, and each adheres to the dimensions once preferred, which seems to prove that, between certain limits, all

* It would be interesting to know the cost of repairs to breaks and the ensuing damages for the last 40 or 50 years, or since the enlargement of 1835-62 was fully completed. Without having the figures at hand the writer has little doubt that, on the average, the cost of such breaks would have paid the interest on the first cost of properly constructed core walls.

TABLE No. 1.

Name of Rhine marine steamer.	Tonnage.		Length.	Beam.	Draft, loaded.	Depth to deck.	Year in which the vessel was built.	Number of voyages per year (out and back) = one voyage.	Destination.	Name of Owner.
	Gross.	Net.	Ft.	Ft	Ft.	Ft.				
Arion	290	170	118	29.6	9.6	11.8	1874	17	From Cöln to Bremen.	Dampfschifffahrt-Gesellschaft "Neptun," at Bremen,
Jason	344	197	140	22.4	10.10	12.5	1890	16	" " Lubeck.	" " " "
Iris	343	201	141	22.2	10.2	12.5	1890	16	" " "	" " " "
Flora	344	196	141	22.4	9.10	12.6	1891	20	" " Bremen.	" " " "
Themis	475	345	160	24	10.10	11.9	1891	13	" " Stettin.	" " " "
Saturn	478	346	159	23.4	10.10	11.9	1891	13	" " "	" " " "
Luna	468	279	160	24	11.2	12.5	1892	13	" " Dantzig.	" " " "
Rhea	492	293	160	24	12.6	13.4	1892	12	" " Köningsbergen.	" " " "
Pax	513	301	160	24	11.10	12.6	1893	16	" " Hamburg.	" " " "
Tortuna	513	304	160	25.3	11.6	11.11	1893	12	" " Dantzig.	" " " "
Stella	479	294	151	23.10	11.2	12.5	1895	13	" " "	" " " "
Thalia	465	286	151	24	11.6	16.1	1896	17	" " Hamburg.	" " " "
Pollux	518	319	165	25.9	11.6	15.1	1896	13	" " Stettin.	" " " "
Castor	519	320	164	24	10.2	16	1896	17	" " Hamburg.	" " " "
Venus	626	361	171	26	13.2	16.10	1897	10	" " Köningsbergen.	" " " "
Phädra	619	372	168	27	13.2	16.5	1898	9	" " Riga.	" " " "
Ariadne	620	373	168	27	12.6	16.5	1898	9	" " "	" " " "
Egeria	627	381	171	24.8	11.6	17.1	1898	12	" " Köningsbergen.	" " " "
Ruhrort	389	232	161	24.1	9.6	11.10	1896	14	" " Hamburg.	Dampfschifffahrt-Gesellschaft "Hamburg," at Hamburg.
Düsseldorf	158	42	107	20.10	10.2	11.10	1897	14	" " "	
Köln	400	242	161	24.1	10.2	11.10	1897	14	" " "	
Industrie	839	513	236	27.9	11.6	14.8	1885	30	From Cöln to London, and sometimes from the Baltic to Rotterdam and Duisburg.	Rhein-Seeschifffahrt Gesellschaft at Cöln.
Energie	740	452	236	30.1	11.6	14.5	1887	30		
Rhenania	874	655	207	33.9	12	14.5	1894	12	From Duisburg to different ports of the Baltic.	" " " "
Westfalia	997	603	230	34	12	15.4	1899	12		
Elbing I	455	278	165	27.6	12.4	15	1893	10	From Duisburg to Memel and Elbing.	Elbinger Dampfschiff-Rhederei "F. Schichau" at Elbing.
Elbing II	535	317	180	27.9	12.4	15.2	1895	10		

Mr. Tutein-Nolthenius.

types are profitable. For example, the Hamburg Steamship Company in 1885 preferred steamers about 230 ft. in length, and the new vessel built for it in 1899 is of almost the same size, while the Neptune Company (the largest owner of this kind of steamers), prefers vessels of less length, only increasing from 140 ft. in 1890 to 170 ft. in 1898.

When the Rhine is at an extremely low level—which seldom happens—these steamers cannot load to their full draft, and part of their freight is then stowed in barges, which the steamer tows alongside, until approaching the ocean. Then this supplemental cargo is transferred to the steamer, while descending the river, in order to lose no time by stopping. The barges remain in the river.

The great pecuniary advantage of not transferring freight in an intermediate port is proved by the fact that these companies make greater profit by loading their small marine craft at Cöln, and sending them directly, say to Hamburg, than by building large barges, such as usually carry the Rhine exports to Rotterdam, where the freight is transferred to ocean steamers. And yet these barges carry freight very economically, some being even 328 ft. long, 40 ft. broad and drawing 9 ft.; while the excellent condition of the Rhine estuary allows ocean steamers of any size to enter the inland port of Rotterdam.

Canals of sufficient dimensions are not only a boon to the counties they cross, but to the whole country at large, as they put an efficient check on railway tariffs. For this reason the Netherlands railway freight tariffs are not as high as those of Belgium and Prussia, where canals cannot compete as effectually with the iron road. While in Belgium two-thirds, and in Prussia even three-fourths, of the railway earnings are contributed by the freight traffic, in the Netherlands the revenues from freight-carrying do not amount to 50% of the total income of the iron roads.

Although the Dutch canals are efficient, they still leave much freight for the railroads, as shown in Table No. 2.*

Table No. 2 shows that in bulk the railways carry less than the waterways; in value, the first are favored, which is natural, as articles of great value more easily bear the higher railway rates.

In Table No. 3, the imports from Prussia during the same year, 1894, are analyzed, after abstracting that part of the imports which only traverses the Netherlands. It shows clearly that for the products the waterway is often chosen even though a greater number of consumers is reached more directly by rail; for strangers are mistaken in thinking that a Dutchman always lives near a canal; this is only true for parts of some provinces.

* Tables Nos. 2 and 3 are extracted from a study which the writer published in the Dutch *Economist*, of 1896. The chosen year, 1894, offers no peculiarities, but more recent years would probably show an increase in favor of the river transportation, as the total number of vessels entering and clearing at the Prussian frontier increased from 44 469 in 1894 to 46 089 in 1899, while the average size of the ships was almost doubled.

TABLE No. 2.

Mr. Tutein-Nolthenius.

Total of imports and exports, 1894.	Tons of 1 000 kilograms = 2 204 lbs.			
	By rivers and canals.		By road.	
	Sailing vessels.	Steam vessels.	Common roads.	Railroads.
Imports from Prussia	3 017 585	156 727	42 662	3 236 217
Exports to Prussia	4 440 483	292 777	113 415	944 533
Imports from Belgium	1 962 431	135 149	54 597	1 020 076
Exports to Belgium	1 619 959	129 421	62 324	1 112 335

TABLE No. 3.

Imports from Prussia, for domestic use, 1894.	Tons of 1 000 kilograms = 2 204 lbs.		Value.	
	By river and canal.	By railroad.	By river and canal.	By railroad.
Coal and fuel (wood)	1,425 000	2 255 000	$3 550 000	$5 675 000
Building materials	167 000	32 000	850 000	125 000
Stone for river works (rip-rap)	488 000	.....	175 000	.....
Lumber	38 000	22 000	325 000	175 000
Ore	80 000	17 000	975 000	425 000
Manufactured metal	137 000	163 000	9 325 000	13 175 000
Fabrics	108 000	96 000	8 725 000	7 800 000
Agricultural products	43 000	52 000	3 500 000	2 275 000
Item from the Indies and the Orient	1 000	9 000	50 000	1 350 000
Manure	23 000	32 000	25 000	50 000
Unclassified freight	10 000	4 000	400 000	350 000
Totals	2 520 000	2 682 000	$27 900 000	$31 400 000

In conclusion, although it is evident that a canal from the Hudson to the Lakes will never offer such facilities as the Rhine, the writer is convinced that a canal better adapted to modern needs than the present Erie Canal (which, however, considering the period of original construction, is a masterpiece not equaled in Europe), will be of inestimable value to New York and to the counties it crosses. It will also stimulate the railways to still more economical management, and thus be a profit to everybody.

Joseph Mayer, M. Am. Soc. C. E. (by letter).—The objections to the statements made in the writer's paper refer to the practicable speed and safety of navigation in the proposed channel, the time necessary at terminals, the traffic capacity of the canal, and the amount of traffic to be expected. Mr. Mayer.

As regards the first four, the writer referred to the United States Canal Commission as authority, and mentioned the experience in the

Mr. Mayer. St. Clair Flats Canal, which is of the same dimensions as the proposed ship canal and is dammed off from the shallow water at its sides.

In regard to the safety of navigation it has been suggested that the great length of the proposed canal, which has 102 miles of standard section and 102 miles of canalized river of much greater section, may make such a difference that the experience in the St. Clair Flats Canal is not to the point. Some facts taken from a paper* by *Sir* Charles Hartley, M. Inst. C. E., and from the discussion on that paper, are therefore added.

The Suez Canal was originally built with 72 ft. bottom width, and was 26 ft. 3 ins. deep. It was then deepened to 27 ft. 10 ins. at low water, and enlarged to a bottom width of 118 ft. with side slopes of 1 on 2 in some places, and 1 on 2½ in others; and with a berm on which rests the stone revetment near the water line for the protection of the slopes. A further widening may be undertaken in the near future. The stone revetment on one side is not in good condition. It is not intended to be permanent, and has not been built as well as that on the other side.

There are nine sidings 49 ft. wide and 2 460 ft. long, for the purpose of permitting vessels to pass each other. The length of the canal is 100 miles, 27 miles of which are lakes. The most northerly of these lakes and the longest is really a swamp dammed off from the canal. Eight miles of the Great Bitter Lake is deeper than the original canal, and permits free and unrestricted navigation for this distance. The other lakes are of very small extent. They are shallow and contribute little to the facilities of navigation.

Vessels going in the same direction are not permitted to pass one another. In spite of this rule, which makes the speed of all vessels nearly equal to the slowest, the average duration of transit is 17 hours 22 minutes, corresponding to a speed of 5.76 miles per hour. The regulations forbid a speed greater than 10 kilometers, or 6.21 miles, per hour. The slope protection in many places could not withstand a greater speed without harm. There are observing stations at considerable distances apart, where vessels are not allowed to pass before the lapse of the time corresponding to the maximum allowed speed. Mr. Lionel B. Wells, an English engineer who passed through the canal in 1898, in discussing *Sir* Charles Hartley's paper, stated that the speed limitation is generally disregarded between observing stations, and that a speed of 8 knots an hour is frequently attained for short distances.

The yearly traffic is about 3 600 vessels of 9 000 000 net tons. The tidal current in the southern section attains sometimes a velocity of 2.9 miles per hour.

* "A Short History of the Engineering Works of the Suez Canal," *Min. Proc.* Inst. C. E., vol. cxli.

Here is a canal which carries safely an enormous traffic, which is half the width of the proposed canal between the Lakes and New York, and in which there is a strong current. It has about the same length as the standard section of the latter. It does not appear reasonable, therefore, to doubt that the latter, with practically no current, will furnish a safe channel for a very much larger traffic. Mr. Mayer.

The regulations on the Kaiser Wilhelm Canal between the Baltic and North Seas allow a speed of 9.3 miles (15 kilometers) per hour for vessels of less than 16 ft. 5 ins. draft, and $7\frac{1}{2}$ miles (12 kilometers) per hour for vessels of larger draft. The standard cross-section of this canal is 4 520 sq. ft.

Mr. Fülscher, an engineer on this canal, in discussing *Sir* Charles Hartley's paper, states that vessels having a midship-section of not more than one-sixth of the cross-section of the canal suffer but little reduction of speed therein, as compared with their speed in open water.

The proposed canal between the Lakes and New York has a standard section of about six times the midship-section of the vessels intended to pass through it.

As appears from Mr. W. H. Hunter's discussion, 8 miles an hour is a speed frequently attained on the Manchester Ship Canal. Mr. Elnathan Sweet also substantially confirms the estimate of speed adopted by the writer, and bases his view on experiments made in recent years in Germany and France.

The writer has assumed a speed of 7 miles in the standard section and 9 miles in canalized rivers of much wider section. It is evident, from the facts stated, that speeds of 1 mile more than those assumed would have been more nearly in accord with them.

As regards the time spent at terminals, two cases have to be considered : Vessels loaded with bulk freights, like ore, coal or grain, can be loaded and unloaded by special machinery, which will be provided wherever a large amount of freight of this kind is to be handled. Experience on the Lakes shows that during the whole navigation season the average time spent in harbors is about 3 days per round trip, and the assertion that this time will be 10 days is based, not on theory or experience, but on unreasonable prejudice. Vessels loaded with miscellaneous high-class freight need spend not more than 1 week per round trip at terminals, as is shown by the records of the steamers of the American Line, which are scheduled to make one round trip between New York and Southampton every 3 weeks.

The writer's estimates of cost referred to low-class bulk freights, and not to high-class freights. The difference in cost between the different classes, however, would not be more than on railroads.

Transfer of bulk freights to other vessels becomes superfluous as soon as a ship canal exists, as there is no necessity of adhering to the

Mr. Mayer. present expensive mode of transporting bulk freights from the West to Europe, or points on the Atlantic Coast which cannot be reached by canal boats.

Regarding the capacity of the canal proposed, the estimate of the United States Canal Commission was quoted, and the calculation of the proper tolls was based on this estimate.

The capacity of the canal is governed by that of the locks. Present experience at Sault Ste. Marie, and the prevailing average size of Lake and ocean vessels, indicate for the locks proposed a much smaller capacity than that given. But it is evident that what is wanted is not the present capacity of the locks but that at the time when the amount of freight will have grown to be nearly equal to it. On the Suez Canal the average net tonnage of the passing vessels increased from 1 170 tons, in 1873, to 2 640 tons, in 1898. A large increase in the average size of vessels may be expected during the next 20 years, which would increase the capacity of the locks to the same extent. The present capacity of the Sault Ste. Marie locks, therefore, is no direct measure of what the locks on the proposed canal will be able to do. The following letter, received from Mr. Noble in answer to a request, will remove any doubts on this subject:

"CHICAGO, DECEMBER 1ST, 1900.

"Mr. JOSEPH MAYER,
"No. 1 Broadway, New York, N. Y.

"DEAR MR. MAYER,—The estimates of cost for the Deep Waterway are based on a single system of locks for single lifts and a double system where two or more lifts are combined. It is assumed that the cargo of a fully loaded freight ship is twice its net register, that its east-bound freight will be in full cargoes and its west-bound freight one-fourth as much. This makes the total freight one and one-quarter times the net register.

"The capacity of a single lock is determined by investigation to be 25 150 000 tons of freight in a navigation year; of the Lewiston double flight of six combined lifts, of 40 ft. each, the capacity is 35 801 000 freight tons. If the capacity of the single locks should be reached, by doubling them the capacity could be increased to 35 801 000 without increasing the facilities of systems of two or more lifts.

"In arriving at these amounts the following method was pursued:

"Ships are to be locked singly. The average tonnage, net register, is assumed to be 2 500, corresponding to 3 000 tons of freight for a round trip. This average tonnage is greater by far than the present average on the Lakes, but the ships now building (and for the last five years) for the freight-carrying trade exceed this very much. These large ships are crowding the others out, and by the time the Deep Waterway could be built the small ship will not be an appreciable factor in the business. This tonnage is less than the present average at Suez, where it is increasing quite rapidly.

"The size of type ship being thus arrived at, the theoretical time of lockage was calculated and the resulting tonnage per year. This was greater than could be handled practically. To obtain a coefficient the records of the St. Mary's Falls Canal were used.

"In 1894 all the business was done by one lock, locking generally two or more ships at once. The delays to ships awaiting lockage were large, reaching what may be considered an economical limit. It was determined what change in time of lockage would have taken place if ships had been locked singly; if the ships had been of the larger size assumed for the Deep Waterway; and if the time for filling and emptying the locks had been changed to conform to the time for the locks of the Deep Waterway. Correcting the tonnage actually passed at the St. Mary's Falls Canal to these changed conditions, we have the tonnage which a single lock of the Deep Waterways would have passed with the same sundry delays and the same idle time as occurred at the St. Mary's Falls Canal in 1894 and also with the same loss of time to shipping while awaiting lockage, which loss of time, as already stated, was considered to establish the economical limit of capacity of the waterway. This tonnage was found to be 0.621 of the theoretical calculated capacity, and was considered the best coefficient available. This coefficient was then applied to the theoretical calculated capacity of each system of lockage. Mr. Mayer.

"While the method may not be wholly satisfactory, I do not know of any better one. At no other ship canal in the world has the lockage capacity been reached.

"The traffic capacity figure you have used is probably the one above given with single locks duplicated. I believe the capacity estimates to be safe, and with the information now existing I do not think anyone can successfully controvert them.

"Very truly yours,
"A. Noble."

A considerable difference in the real capacity of the canal, however, will not materially affect the argument for or against it, as there is no reasonable doubt that it will be very profitable as soon as the freight transported through it is equal to its capacity. The cost of increasing the latter is comparatively small.

A more important question is that of the amount of freight to be expected. Major Symons, in his report of 1897, has made an estimate in which he gives the amounts of the different kinds of freight which he expects for a canal 24 ft. deep on the Oswego Route, and the writer was fully aware of the fact when this paper was written, but did not mention the estimate, because no evidence is given in that report to support his mere assertions, and because the writer believes it to be impossible to make a detailed estimate of the probable traffic. If anybody had made an estimate 20 years ago of the probable traffic of the inter-lake channels, he would have either greatly underestimated the traffic, or have been laughed at as visionary. The idea that iron ore in any quantity would be transported to Pittsburg from the Lake Superior Region would have been found to be utterly ridiculous and as indicating the ignorance of the author of it.

We now know, from experience on the Lakes, that a great reduction in the cost of transportation will develop an enormous amount of new business, and that it will deflect from distant and more expensive routes business already existing. The development of new business

Mr. Mayer. is a relatively slow process, requiring the establishment of new manufactures along the new route, while the deflection of existing business from other means of transportation will take place much more quickly. It is true that no such transport of heavy cheap goods over great distances takes place on the line of the future canal as exists now on the Lakes, but such transport would not exist along the lake routes if lake freight rates were the same as those by rail. To any careful observer the experience on the Lakes should show two things: First, that the new business developed by the lowering of freight rates is more than half the total. Second, that one cannot estimate in detail the new business which will be developed by a great reduction in cost of transportation.

One can with some approximation estimate the amount of existing transportation which will be transferred from other lines to one very much cheaper, but not the new transportation which will be created. It is evident that the canal proposed will obtain most of the grain and much of the provisions passing from upper lake points to the Atlantic coast and Europe; that it will obtain lumber in large quantities in both directions, besides salt, building stone, cement, brick, coal, iron ore, etc.; but to put definite quantities behind all these items, shows only the habit of their author to make positive statements in regard to subjects which he does not know.

The principal data which permit making an approximate estimate of the freight to be expected are furnished by the amount of freight obtained through the Lake rates, due to the improvement of the interlake channels, and by a comparison of the population and the number and importance of the harbors at the two ends of the lake region with those at the two ends of the proposed canal. Since the visible makes a greater impression on us than the invisible, we are apt to underestimate in such a comparison of an existing waterway with a proposed one the amount of freight which may be expected by the latter. The development of the iron mines in the Lake Superior Region is an accomplished fact, and their product goes at present largely to Pittsburg, therefore the argument is ready at hand that there are no iron mines on the new canal, and that the ore of the western mines does not go East. A considerable part will go East after the canal exists, and other sources of freight, as unknown now as the Lake Superior mines were twenty years ago, will arise as soon as heavy goods can be transported cheaply. The quantity of goods produced, transported and consumed is largely dependent on the size of the population which produces and consumes them, and the cheapness of transportation. And the possibility of transporting them by water from producer to consumer depends mainly on the existence of the appropriate channels and the number and importance of the harbors available. In comparing, therefore, the relative amount of freight which may be expected

to pass through the Detroit River and the canal proposed, it is reasonable to take into consideration the populations and harbors connected by the two waterways. If this is done, and allowance is made for the natural increase of business during the next twenty years, it appears to the writer to be very moderate to estimate the then existing traffic through the proposed canal as equal to its capacity. Another argument against a ship canal on the Oswego Route is to the effect that Canada would build a ship canal to Montreal and deflect business in that direction. The larger part of the Dominion is chiefly interested in such a canal on account of the cheap transport to Europe and the United States which would be created thereby. A ship canal from Lake Ontario to Montreal would not materially cheapen transport to these countries after the American ship canal exists; it would be in a precarious position without control of a ship canal around Niagara Falls; and it would be such a ruinous undertaking for a small and poor country like Canada that it is an insult to our neighbors to think them capable of it. Mr. Mayer.

An estimate of the water supply needed at the summit level has been made by one of the discussors, and an objection against the Oswego Route is based thereon. This discussor asserts that the water supply needed at the summit level for each passing vessel is equal to the lock area multiplied by the sum of the lifts of all the locks.

It is reasonable to provide water supply for the full capacity of the canal. At each end of the summit level is a lock. From the passage of the sill by a vessel entering a lock from above, it takes a certain minimum time for this vessel to go to the lower level, move out, let another vessel pass in, rise up, move out, and the next down-going vessel to advance to the sill. This period of time is required for one cycle of lock operation, and will pass one vessel down, another up. For a given lock area, it varies somewhat with the litt at the lock. One lock chamber full of water is required per cycle, or a volume equal to the area multiplied by the lift. The shortest time required for one cycle is found by observation of existing locks of similar size and lift. It is easy to estimate the influence of a change in lift on the time required for one cycle. The experience at the locks of Sault Ste. Marie allows, therefore, a very close estimate of this time to be made. From this the number of cycles per 24 hours is obtained, and the quantity of water needed for the two locks at the end of the summit level can easily be estimated. If the amount of leakage per 24 hours in the summit level and the two adjacent locks, and the evaporation per day, is added to the foregoing amount, the water needed at the summit level is known. The latter items are relatively small if the canal is well built. This is all the water needed at the summit. And if the two adjacent locks have the greatest lift of those on the same side of the summit, the water needed for lockages at the summit is sufficient for all lockages below, provided the

Mr. Mayer. level water surfaces between any two succeeding locks, in comparison with the lock chambers, are large enough to permit their filling twice without reducing the depth too much on the level. Any additional water needed, however, may be supplied below the summit level. The problem of water supply is therefore not so serious as it would be if the estimate mentioned were correct. The argument based on this difficulty becomes invalid on account of the gross error in the estimate of the water needed.

It has been suggested that it would probably be better to make the canal somewhat deeper and narrower. The writer's studies of the opinions of experts on the Suez Canal lead him to believe that the same area of cross-section as proposed by the Commission, with a depth of 24 ft., would be more satisfactory. At a depth of 21 ft., this would give a width of 192 ft. instead of 215 ft., and a bottom width of about 177 ft., with slopes of 1 on $2\frac{1}{2}$. The Commission, however, undoubtedly had good reasons for the cross-section selected. The width chosen by it substantially agrees with that proposed by the International Commission which investigated the proper means for increasing the capacity of the Suez Canal. But the depth recommended by that Commission was 9 meters, or 29 ft. 6 ins.

It has been correctly stated in the discussion that most of the ocean traffic is carried on in comparatively small vessels which could easily pass through the proposed canal, and that the large vessels are very few and play a small part in the freight traffic, especially in the coasting trade. It is evident, therefore, that for most of the traffic small vessels are more economical than very large ones. The assertion that vessels capable of passing through the proposed canal could not with economy cross the ocean is not supported by the facts.

Since the locks proposed would only be able to handle the traffic for at most twenty years, additional locks would soon be required which could then be built of a size and depth fit for the demands upon them. The canal could then be deepened should it appear to be desirable.

Another very important question touched by Mr. North, is the advisability of levying tolls. The writer does not deny the advantages which any section of the country would derive should the United States decide to pay a large part of the freight charges in that section only. This is substantially what the proposition of building at the expense of the United States a costly canal, which is to be toll free, amounts to. The prospect of inducing people of other sections of the country to vote for such a scheme, however, is very slender, and, in order to secure a majority of votes, as proposed by Mr. Thomas Curtis Clarke, it would be necessary to couple it with other schemes beneficial to other parts of the country. The writer believes that the reduction in cost of transportation to be brought about by this canal

Mr. Mayer.

is so large that the levying of proper tolls will not materially diminish the amount of freight which will pass through it; and it is ungenerous and inexpedient for the section of the country to be benefited to expect other sections, not so fortunately situated, to help in paying the yearly expenses incurred for it.

For the purpose of illustrating from an economic standpoint the objections to a toll-free canal, a simplified example containing the essential features of the problem will be chosen.

There are quarries at a town, "A," where a cubic yard of stone costs $2; in another town, "B," are quarries where a cubic yard of equally good stone costs $3; the cost of transportation between the two places is $1.50 per yard. In this case each place uses its own quarries. The State intervenes and assumes two-thirds of the cost of transportation.

Then the town "B" will obtain stone from "A" at $2.50 per yard. The actual cost of this stone is $3.50 per yard, of which the State pays $1. The effect of the interference of the State is that more labor is spent for the stone used at the town "B" than before.

Stone has become actually dearer though it is nominally cheaper. Other effects will be produced, among them, losses to the quarry owners of the town "B" and gains to those of the town "A"; generally the latter effects alone are dwelt upon by advocates of such State interference. When the State omits to charge a reasonable toll for the use of a canal which it builds it not only enriches one section of the country at the expense of the rest, but it increases the production of things at a distance which could really be produced cheaper at home; it thereby increases the amount of labor which has to be expended for obtaining a given amount of goods. There are cases, however, and the Manchester Ship Canal seems to be one of them, where the principal benefit obtained by a canal is the lowering of excessive monopolistic freight rates on competing railroads, and where the attempt to levy tolls covering the yearly expenses of such canals would be destructive of their usefulness. The writer believes that a toll-free barge canal of large capacity, from the Lakes to New York, would have this effect. And the advocates of a barge canal wisely refuse to recommend tolls, as they would destroy most of its usefulness. A barge canal of small capacity, however, would not answer this purpose, as the railroads would find it to their advantage to let it have all the business it could carry, and ignore its freight rates.

The rail freight rates in this country, however, are only about one-third of those in England; the possible reduction is small, and the effect of a competing canal, therefore, very limited.

The tolls proposed for the ship canal by the writer, however, are much smaller than the expenses incurred for transfer on a barge canal; the former is therefore superior, as it pays its way and offers larger benefits to the public.

Mr. Mayer. The writer's criticisms of the barge canal project were mainly directed against the arguments of the New York State Canal Commission, which attempts to prove that a barge canal is desirable, independent of the incidental advantages of lower railroad freight rates due to it.

Theoretically, it would be best, in canals which are not used to their full capacity, to increase the amount of freight using the canals by varying the tolls for the different kinds of merchandise, taking into account origin and destination, in proportion to the value of the service rendered by the canal, charging on no part of the freight more than the traffic will bear. For a canal which is used to its full capacity a uniform toll is the best in every respect. The value of the service rendered by the proposed canal is greatest for freight which saves transfers. The principle of charging in proportion to the number of transfers saved seems to be, therefore, the nearest practicable approach to an ideally perfect system of tolls.

The tolls proposed by the writer were calculated for an annual expense of $9 000 000, allowing for 3% interest. If the United States can obtain the money for construction at 2% interest, the annual expense will be only $7 000 000, and the tolls given would be sufficient, even if the estimate of traffic is considerably in excess of the facts.

Mr. Thomas Curtis Clarke's remarks are interesting, and the writer thinks that the scheme recommended by him for consideration is worthy of careful investigation, which is likely to show that it is not only feasible but economically desirable, weighing the advantages to be gained with the cost of their attainment. If the scheme were as well known in all its aspects, and if its economic merits were equal to those of the canal here considered, the writer would think it advisable to combine the two; but, for the present, he would prefer that those most interested in the eastern canal would come forward, frankly declaring their willingness to pay for the yearly cost by proper tolls, and advocating the passage of a law in Congress providing for its construction on these terms.

It has been asserted that Lake vessels would be very uneconomical on the ocean. The writer does not believe that the equivalents, on the size of which the whole argument depends, have inherent probability, in the face of the actual transportation charges on the Lakes and ocean. All the difference in these is explainable partly by the present small depth of lake channels, and partly by the smaller distances on the Lakes. If a canal of either 21 or 24 ft. depth existed, vessels would be built adapted to both Lake and ocean traffic, and their disadvantages for either would be small in comparison with the savings accomplished by the avoidance of transfers.

The superiority of a canal 30 ft. deep can only be shown by assuming an enormous traffic. Though the writer believes that such a traffic

will exist on this route in the near future, he does not think that after this discussion it is possible to convince a sufficient number of people to induce action by Congress in favor of such a canal. The smaller canal will be more profitable at the beginning, and for this purpose does not require an amount of traffic which appears improbable to the majority of judges. Mr. Mayer.

The capacity proposed by the United States Canal Commission for the beginning is, as appears from Mr. Alfred Noble's letter, 25 000 000 tons, which can be increased to 36 000 000 tons by doubling the single locks. If one of the two rows of locks, in the places where there are several locks in a chain, were made 30 ft. deep, the canal could be easily increased to 30 ft. depth whenever the traffic required an increase of capacity beyond the 25 000 000 tons. This ought to unite all the advocates of a ship canal, because it will fulfill the wishes of those in favor of a 30-ft. canal as soon as the growth of traffic shows this to be advantageous.

The purpose of this paper was to make it evident by the discussion which it would call forth, that the preponderant judgment of those who have studied this question is in favor of a ship canal. Mr. Wisner's paper and the writer's have accomplished this purpose. The objections which have been raised against a ship canal have been effectively answered in the discussion, by those most competent to do so; and many who were either ignorant of, or indifferent to, the subject, have been convinced or made more enthusiastic in favor of an enterprise which is the most important engineering work of the near future.

GEORGE Y. WISNER, M. Am. Soc. C. E. (by letter.)—It is gratifying to note the advance which has been made in general knowledge on the waterway problem since the discussion in the *Transactions* of the Society for June, 1898.* Mr. Wisner.

The present papers attack the problem from entirely different standpoints and by different methods, and arrive at practically the same results; while the discussions, which have been contributed by some of the ablest waterway engineers in the world, although not in harmony as to the actual dimensions which should be adopted, in no way controvert the facts on which the conclusions in the papers were based.

One of the principal issues raised in the writer's paper was that estimates of transportation rates by different routes should in each case include all items relative to the cost of construction, maintenance of route, and the cost of moving the expected commerce between terminals, which in any way affect the fixed charges properly chargeable to the rates of the respective routes.

* *Transactions*, Am. Soc. C. E., Vol. xxxix, page 273; "The Economic Depth for Canals of Large Traffic," by Joseph Mayer, M. Am. Soc. C. E.

Mr. Wisner. Major Symons calls attention to the writer being a strong advocate of ship canals; yet, in all of his own estimates for transportation rates on his proposed barge canal, he assumes the waterway to be constructed and maintained at public expense, and then attempts to show the great saving in transportation rates, as compared with those on the routes where all fixed charges for construction and maintenance must be taken care of in the transportation rates.

The writer has endeavored to treat each route in exactly the same manner, and wherever fluctuating values have been used, the conclusions drawn are based on results from which the errors from such sources are practically eliminated; and if such methods may be termed those of an advocate, then those adopted by Major Symons need qualifying with a much stronger phrase.

It is immaterial whether the routes be constructed and maintained at public expense, or whether the fixed charges be made a part of the transport rate; the result to the producers of the country is the same. If the route is worthy of being constructed at public expense, it is fair to presume that the people of the whole country are to be benefited, and whatever saving may accrue in transportation rates from Government construction indirectly becomes a tax on the producers who use the line.

If, therefore, when all direct and indirect benefits are considered, a route cannot be shown capable of furnishing better rates with fixed charges included than its competitors, we must conclude that it is not worthy of construction.

In discussing the relative merits of these different proposed waterway routes, there are several important considerations which must not be lost sight of, if a correct and satisfactory solution of the problem is expected.

Existing knowledge as to the natural physical conditions of the routes, and the economical type of freight carrier which can be best utilized on the respective waterways in the transport of domestic and foreign commerce, must be fully considered, and all conclusions based on sentiment eliminated. While most of us would take great pride in such a grand achievement as that of extending the ocean waterways to the ports of the Great Lakes, we must inevitably answer the question, "Will it pay?" before asking the producers of the country to contribute their earnings for its construction. Not that the reduction in transportation rates must be such as to warrant a private company taking up the project for profit, but that the result to the whole country from direct reduction of rates and from resulting development of new commerce and industries will show a balance on the right side.

Under the most favorable conditions to be expected, it will be at least ten years before either of the proposed waterway routes can be opened for business. The relative movement of domestic and foreign

commerce which will exist after that period is the important factor on which both the type of waterway and of freight carrier must be based. At the present time about one-fourth of the wheat raised in the United States is exported; but from the increase in population which may safely be predicted, the present surplus of wheat raised will be required for domestic consumption within less than twenty years, and unless the annual yield can be increased, the export of grain must be eliminated from the calculation. Whatever the future may have in store for the grain business of the country, it is safe to say that the export of raw materials will greatly decrease, and the export of manufactured products largely increase in the near future, which implies a decreasing tonnage for the corresponding value of the commerce. Mr. Wisner.

The Commissioner of Navigation gives the weight of exports from the United States in 1899 as follows:

TABLE No. 1.—Weight of Exports in 1899.

	Value.	Weight.	Value per ton.
		Tons of 2 240 lbs.	
Articles, in terms of weight	$904 827 281	25 569 729	$35
Articles estimated by experts	85 370 277	602 482	142
Lumber, boards and shingles	20 138 053	2 142 424	9
Miscellaneous manufactures	193 595 611	967 978	200
Total	$1 203 931 222	29 282 613	$41

It will be noted from Table No. 1 that the entire exports in 1899 only amounted to 29 282 613 gross tons, of which 25 569 729 tons, worth $35 per ton, were products, the export of which is likely to greatly decrease in the near future, and that 967 978 tons, worth $200 per ton, were manufactured products, the exports of which are increasing rapidly, and will be likely to comprise the principal part of our foreign commerce during the era for which the the waterway must be constructed. It therefore appears that the waterway, if constructed at all, should be more for the purpose of distribution of products for domestic consumption than for the accommodation of foreign commerce.

The economical dimensions for a waterway, and for the freight carriers which use it, are functions of the distance between freight terminals.

In ocean traffic, with from 3 000 to 5 000 miles between terminals, there is no question that larger ships will be economical, and will be built as fast as the improvement of the depth of terminal harbors will permit; but, on the Great Lakes, where the length of haul is limited

Mr. Wisner. to 1 000 miles or less, the limit in size of economical ship construction has already been reached, and with unlimited depth in the connecting channels of our lake waterways it will not pay to construct freight carriers for lake service alone any larger than those recently put in the service. This statement may seem somewhat strong, but the facts are that with a haul of less than 1 000 miles, the running expenses and fixed charges for ships over 480 ft. long, 52 ft. wide and 19 ft. draft, increase more rapidly than the profits from increase of carrying capacity.

Table No. 2, giving the dimensions, horse-power, speed, cost of ship, running expenses and cost of transport per ton-mile for different types of carriers, is based on actual lake practice and experience, and has been prepared from data furnished by Mr. Frank E. Kirby, who is doubtless the best authority in the world on this class of ship construction.

TABLE No. 2.

Dimensions and draft of ship, in feet.	Number of propellers.	Horse-power.	Speed per hour, in miles.	Carrying capacity, in net tons.	Pay roll and subsistence, per day.	Fuel, oil and waste, per day.	Cost of ship.	Cost of transport per ton-mile, in mills.
480 × 52 × 19...	Single	2 200	12.5	8 600	$60	$117	$387 000	0.128
480 × 52 × 23...	"	2 480	12.5	9 600	60	129	462 000	0.129
480 × 52 × 27...	"	2 806	12.5	11 760	62	143	554 400	0.121
500 × 54 × 27...	"	2 930	12.5	12 600	62	149	612 400	0.120
520 × 56 × 27...	Two	3 100	12.5	13 300	80	155	705 600	0.129
540 × 58 × 27...	"	3 200	12.5	13 980	80	159	771 400	0.130
550 × 60 × 27...	"	3 330	12.5	14 100	82	165	828 400	0.136
480 × 52 × 19...	Single	3 650	15.0	7 650	72	154	410 000	0.141
500 × 54 × 27...	"	4 850	15.0	10 000	76	204	661 200	0.151

It will be noted that for speeds of over 12.5 statute miles per hour the rate increases. If the lines of the vessel be adapted for obtaining greater speed with less power, the carrying capacity is decreased and the cost of carrying correspondingly increased. In computing the cost of transport per ton-mile the prices for labor and materials used are the same for each type of vessel, and, therefore, any variation which may arise from fluctuation of prices will be practically eliminated in the relative cost of transport for different types of ships.

The rate per ton-mile in Table No. 2 only includes those items which enter into the cost of carrying a ton one mile in the open lake. If we take into consideration the greater loss of time by the larger ships at terminals, the difference in cost of transport becomes still less, as shown by Table No. 3, which is a computation of transport rate for the first and fourth of the steamships given in Table No. 2.

TABLE No. 3.—Transport Rate Per Ton. Mr. Wisner.

Dimensions of ship, and draft.	480 × 52 × 19 ft.	500 × 54 × 27 ft.
Sailing time of round trip	7 days.	7 days.
Detention at terminals	3 days.	4 days.
Wages and subsistence	$600	$682
Fuel, oil and waste	909	1 183
Insurance on ship	477	830
Insurance on cargo	860	1 260
Miscellaneous expenses	30	40
Interest on investment	530	922
Deterioration, etc	530	922
Profit to shipowner	400	600
Total	$4 336	$6 439
Rate per ton	0.378	0.383

It will be noted from Tables Nos. 2 and 3 that the actual cost of moving a ton of freight 1 mile in the open lake is such a small percentage of the transport rate which must be charged to transact the business, that the length of haul and the amount of detentions at terminals are the important factors necessary for determining the economical dimensions for freight carriers, and, consequently, of the water routes to be used by them.

The rate computed in Table No. 3 is for ships adapted for both lake and ocean traffic, and used for lake traffic only. If freight be carried between Lake ports and New York in vessels adapted for only lake and waterway business, the actual savings on the Lakes by using the deeper-draft vessels would be less than one-half of the estimated fixed charges arising from the excess of cost of construction and maintenance of deeper channels, as stated in the writer's paper.

Since at least three-fourths of the freight carried on the Lakes is for domestic consumption, and because domestic traffic must increase much more rapidly than that with foreign ports, it seems evident that if any waterway be constructed it should be the one best adapted for the distribution of products and manufactures for domestic use.

It is generally conceded that to produce the best results, a waterway from the Lakes to the Atlantic should have dimensions which will permit the passage, at economical speeds, of ships best adapted for the traffic of the water routes connected.

It is also established from the cost of vessel construction on the Lakes, and the cost of transport in carriers of different speeds and dimensions, that the maximum size of steamer for economical transportation for hauls of less than 1 000 miles has been reached in lake practice; from which it appears that the only legitimate reason for constructing waterways more than 21 ft. deep will be solely to accom-

Mr. Wisner. modate foreign commerce between lake and foreign ports. The only saving to be obtained by the use of deeper waterways will be the cost of transfer at New York of products destined for foreign ports, and, since all traffic for the Atlantic coast trade would have to be transferred at New York, if carried in the larger ships, it is probable that the 19-ft. carrier would be more economical on the average, no matter how large the volume of commerce be assumed.

Without regard to the pleasing sentiments awakened by the proposition to open up a waterway from the Great Lakes to the seaboard, capable of accommodating the largest ocean freight carriers, the cold facts must be faced that the interests of the producers of the country are but the collective benefits to be derived by individuals, and unless it can be shown that the benefits to be secured from the construction of a new route, with all expenses included, will exceed those obtained from routes now in use, it will certainly never be built, no matter whether it be a $60 000 000 barge canal or a $300 000 000 waterway for ocean steamships.

Major Symons' statements that "Mr. Wisner has certainly jumped at a conclusion which is in no manner justified by the facts and present data," and that "his premises are entirely in error," seem peculiar, to say the least, when it is considered that he was well aware when he wrote his discussion that the St. Lawrence Canals were actually open for business for the entire navigation season of 1900.

It is technically true, as he states, that the Canadian Canals have not yet been entirely completed. Neither has the St. Mary's River improvement been fully completed, yet its commerce in 1900 was over 25 000 000 tons, while on the new St. Lawrence Canal only one fully loaded freighter is reported as having passed through. Why? Simply because, as stated in the paper, any waterway requiring transfers will fail to divert freight from the lake and railroad lines.

It is a notable fact that the steamers now being constructed for lake and ocean commerce through the Canadian Canals are for 20 ft. draft, it being considered more economical by the builders to lighter through the canals than to undertake transportation on the Lakes with ships of only 14 ft. draft.

The fact mentioned that "the Canadian Government and private parties have only just commenced work at Port Colborne and Montreal to prepare for the traffic which they expect to go through that commercial highway," is one for which the Canadian officials would like to have some legitimate reason. From the tenor of recent articles in Montreal papers, they evidently fear that the desired improvements may never materialize. It must also be borne in mind that the volume of freight for domestic consumption is so large that it practically controls the route followed by foreign trade in the same commodities, and must to a great extent prove a strong handicap for the Canadian route.

Mr. Wisner.

The writer did not state that the Canadian canals were failures, as implied in Major Symons' discussion, but that they had thus far failed to divert traffic from established routes, and that any waterway of less depth than required for the passage of the best type of lake freighters cannot materially modify the transportation rates over existing routes.

Major Symons' comparison, of the effect of the enlargement of the Erie Canal, to the economy of an 8 000-ton steamer over one of 2 000 tons capacity, is not apropos.

The conditions which have caused the decline of traffic on the Erie Canal since 1880 cannot be eliminated by the construction of a waterway only 12 ft. deep, while the economy in the use of larger freight carriers on the Lakes depends simply upon the ratio of the running expenses and fixed charges, due to cost of ship, to the carrying capacity for steamers of different dimensions.

While not prepared to stand sponsor for the exact ratio of power required, respectively, for towing wooden and steel barges, the writer is surprised that an engineer of Major Symons' high standing should for one moment question the fact that the resistance of wooden surfaces to movement through water is largely in excess of that of steel, especially in the case of barges in canals and shallow rivers, where the bottoms cannot be maintained long in good condition except by constant repairs. The fact that wooden ships, with bottoms in the condition similar to that of barges in use on shallow streams, offer great resistance to movement through the water, is so well known that comment is unnecessary. If further evidence is needed to convince Major Symons of his error, a careful study of the resistance of wooden and steel conduits to the flow of water should certainly be sufficient.

If, as stated in the discussion, "one of the strongest arguments in favor of a barge canal following the general route of the Erie Canal, is that business upon it can be done in cheap, light, wooden boats," the project is certainly based upon a very weak foundation, for it is generally admitted that in vessel construction wood must give way to steel long before either of the proposed waterways can be constructed.

While it is true that the insurance rate on the present small canal boats is much less than that used in the estimates given in the paper, it should be noted that the risk on 1 000-ton barges in fleets of five or more, in a 12-ft. waterway and through the lakes and rivers traversed by the route, will be practically the same as that for a steamer having a tonnage equivalent to that of the fleet.

On page 80 of Major Symons' report on a ship canal from the Great Lakes to the navigible waters of the Hudson River, it is stated that:

"The ordinary rates of insurance on the Lakes are 3 to $3\frac{1}{2}\%$ on steel vessels. No insurance man interviewed thinks that the rates would be less for vessels navigating the canal, while many announced that they would be higher."

Mr. Wisner. It is not safe to estimate for lake and river insurance at less than $4\frac{1}{2}\%$, but, admitting that this rate is too high, the discrimination is really in favor of the canal barge, for the reason that the cost of vessels per ton of carrying capacity is much greater for steamships than for barges, and, therefore, if a less rate be introduced in Tables Nos. 3 and 4 of the paper, the showing for the barge canal would be made even worse than stated.

Major Symons is in error when he states that the cargo insurance used in Table No. 3 of the paper is increased in some unexplainable manner, for the reason that exactly the same rate is used as in his report, but the amount is computed for the cargo carried in both directions, instead of making the shipper pay the insurance on the west-bound freight, as was done in the barge canal estimates. If forcing the shipper to pay all items which make estimated transportation rates undesirably large is a correct and fair procedure, the principle should be still further extended and make transportation practically free. Major Symons has apparently made use of this method, so far as the cost and maintenance of barge route and west-bound insurances are concerned, and it would be interesting to know why the same principle should not be applied in the estimates of railroad rates, by omitting all fixed charges for right of way, construction and maintenance of road.

In view of the large experience that Major Symons has had in connection with lake waterway and harbor improvements, it is surprising that he should not be aware that the barges he describes in his reports would be neither safe nor economical for lake transportation as compared with the large freighters now used in the lake service. If such was the case, we certainly ought to expect a much more crowded state of affairs in the Canadian canals than has ever existed.

In Major Symons' reports and discussion great importance is given the fact that "nearly all of the foreign-bound commerce of New York leaves the port as berth cargoes in the large ocean liners," and that anything like quick dispatch at the port of New York would require a complete upheaval and reversal of the methods of doing business in that great port.

To those interested in rapid and economical methods of transportation, this state of affairs is a strong argument in favor of adopting some other method of interior transportation, which will not perpetuate a system which, from excessive terminal detentions, great cost of transfer, and from diversion of traffic to less economical routes, adds materially to the cost of marketing the products of the country. The very fact that the differential rates on railroads to the seaboard all discriminate against New York is proof that New York harbor is the most economical natural outlet for exports, and, instead of perpetuating existing conditions, the efforts should be to increase the receipts of

freight, so that full cargoes can be furnished to ocean freighters. The commerce of New York is taken as berth cargoes for the simple reason that the volume received for export is not what the commanding position of the harbor and its unsurpassed natural conditions for interior communications entitle it to. Mr. Wisner.

With direct deep-water connection with the great producing centers of the Northwest, the railroads would have to discontinue differentials detrimental to the Port of New York, or lose much of their present traffic.

In either event, the export commerce of the port would increase and make it possible to establish methods which would give better dispatch than at present.

The statement that "the data furnished by Mr. Wisner is not at all sufficient to prove that the great freighters could with safety make a speed of 8 miles per hour in the canal proposed by the Board of Engineers on Deep Waterways" needs some substantiation before being accepted. What better proof is needed than that large freighters do make such speeds safely in similar canals every day?

The St. Clair Flats Canal is by no means the only restricted section of the Lake waterways, yet it is a notable fact that no accidents have occurred in these channels, except at sharp curves in strong currents, a condition which has been entirely eliminated in the plans proposed by the Deep Waterway Board.

Mr. Hunter's unqualified endorsement of the writer's estimate, that 8 miles per hour as an average speed would be certainly safe, should settle the question beyond all doubt.

The cross-section of the Manchester Canal is only four-fifths of that of the proposed waterway, yet experience has proved that speeds of 8 miles per hour are safe, and licenses permitting such speeds are now issued.

It is true that strenuous efforts are being made to have some of the narrow channels of the Lake waterways widened to 600 ft., where there are sharp curves and strong currents, but in the plans for the proposed deep waterway to the seaboard, sharp curves are eliminated and wide channels provided in rivers wherever strong currents exist.

In view of the facts that the speed of large freight carriers on canals of similar dimensions to those of the proposed deep waterway has been thoroughly established by actual safe practice, and that the time required at terminals has been fixed by experience extending over many years, the closing statement of Major Symons' discussion, that the estimates of Mr. Mayer and Mr. Wisner are theoretical possibilities, while those for his barge canal are reasonable probabilities, must be regarded as a strong exhibition of over-confidence in his own personal views.

The methods and rapidity of handling cargoes at terminals have

Mr. Wisner.

changed but little in the past ten years, as shown by Table No. 4, which gives the types of large carriers built in 1890 and 1900, and the average time of detentions at terminals for those years.

TABLE No. 4.

Name of ship	*Matoa.*	*Gates.*
When built, and years compared	1890	1900
Length over all, in feet	290	500
Beam, in feet	40	52
Depth, in feet	21	30
Registered tonnage (gross)	2 311	5 085
Draft of water in channels, in feet	15.5	17.8
Average cargo, in gross tons	2 500	7 000
Average time at terminals per round trip, in hours	51	63

Mr. Mayer has covered the relative merits of government and private ownership of the proposed waterway so thoroughly that but little comment is necessary. His idea that a moderate toll might be allowed, to cover all expenses incurred by the nation, would be a serious mistake if put into practice, for the reason that the benefits derived from such a waterway will be as much of an indirect nature in building up new commerce as of direct value in decreasing the cost of transport, and, therefore, to obtain the maximum benefit, it should be made absolutely free to all.

Mr. Schenck is in error in supposing that loss of time from meeting vessels, and from reduction of speed on curves, has not been provided for in the estimates of time of round trips on the proposed 21-ft. waterway from the Lakes to the Atlantic. It is established beyond doubt that a speed of 8 miles per hour is absolutely safe on tangents, and in passing vessels a reduction to one-half speed has been used in the estimates, and for curves a reduction depending upon the degree of curvature, as stated by Mr. Noble.

Mr. North, in his able discussion, refers to "the determination to make 24 ft. the governing depth for the channels of the Great Lakes," as an argument against limiting the depth of the proposed waterway to 21 ft.

If it were a fact that the governing depth of the lake channels was to be fixed at 24 ft. or more, the writer would be fully in accord with Mr. North's views. No project for channels of over 21 ft. depth has ever been seriously contemplated, and, besides, it has been so thoroughly demonstrated that larger ships than those recently constructed will not be economical in the Lake service, that the shipping associations will probably ask the Government to fix the ultimate navigable depth of Lake waterways at 21 ft.

It is true that in contracts for the improvement of Lake waterways

the payment for depths up to 23 ft. is sometimes provided for, but this simply arises from the fact that with some kinds of materials to be excavated, a clear navigable channel 21 ft. deep cannot be made without making occasional cuttings from 1 to 2 ft. deeper than required for navigation. Mr. North quotes the writer as authority for the statement that 40 000 000 tons of freight passed through the Detroit River in 1899. This is not correct. The actual volume carried on the entire chain of lakes was not far from 40 000 000 tons, as stated in the paper, while that passing through the Detroit River probably did not exceed 30 000 000 tons. Mr. Wisner.

Table No. 5 shows the movement on the Lakes for the four leading commodities in 1898:

TABLE No. 5.

Commodity.	Total traffic, in net tons.	Eastward traffic, in net tons.
Grain (including flour)	9 661 411	9 661 411*
Iron ores	13 650 788	11 028 321
Lumber	4 540 000	2 531 180
Coal	8 722 667	.....
Total	36 574 866	23 220 912

The report of the Committee on Canals of New York State gives the total entrances and clearances of registered tonnage at Lake ports in 1898 as 124 046 366 tons. Dividing this by two, the Committee obtains the total lake traffic as 62 023 000 tons.

This, however, is misleading, as to the actual volume of freight movement, which, in fact, was only about two-thirds of the volume indicated by the entrances and clearances at the Lake ports.

The entrances and clearances include those of all pleasure and passenger steamers entering and leaving the ports, which at many of the harbors is an important part of the tonnage. To assume, therefore, that the freight movement through the Detroit River will within a few years amount to 80 000 000 tons is wholly unwarranted by the present conditions or future probabilities.

It is true that the commerce of the St. Mary's River has approximately doubled every six years since 1882, but on the Detroit River the traffic has not doubled in the last twenty years,† instead of in the last six years, as quoted by Mr. North, and it must be remembered that this ratio cannot continue indefinitely, and, in fact, that the condition of the Lake grain and ore trade has already reached the stage where the annual increase of volume of traffic must be much less than heretofore. The unprecedented growth of commerce on the Great Lakes

* Including Canadian traffic through Georgian Bay and the Welland Canal.

† See Tunell's "Statistics of Lake Commerce," page 3.

Mr. Wisner.

has been due to the development of cheaper transportation by the improvement of waterways, and the consequent bringing into existence of new manufacturing enterprises which otherwise could never have been started. While the free improvement of these waterways has often been criticised as undue favoritism of the competitors of the railroads, it is nevertheless true that the great prosperity of the railroad lines which parallel the water routes has been largely the indirect result of the new traffic which would never have existed had not cheaper transport been developed by waterway improvements.

The effect of waterway improvements on the movement of the Lake commerce is well illustrated by the relative volume of flour carried by vessels and on railroads during the period of channel improvements.

In 1866, the railroads carried approximately one-half of the flour between the upper Lake ports and the seaboard; in 1867, three-fourths; in 1877, 94%; and in 1881, 96 per cent.

The improvement of the St. Clair Flats Canal and the completion of the 15-ft. lock and canal at Sault Ste. Marie in 1881, turned the advantage again in favor of lake transportation, so that, in 1882, the Lake shipments of flour were 21%; in 1886, 38%; and in 1889, 48% of the total volume. It is hardly to be expected that this ratio will materially change in the future, for the reason that winter shipments by railroad are certain to continue, and that future reduction in water rates must be small after the completion of the 21-ft. waterway project, which depth, economical transportation, so far as Lake traffic is concerned, will not warrant increasing.

If a commerce of 80 000 000 tons annually through the Detroit River, with a corresponding increase of traffic to the seaboard, can be guaranteed after the completion of a 30-ft. waterway, the writer will heartily concur with Mr. North as to the desirability of such construction. Not that the cost of transport will be less for Lake traffic than with a 21-ft. waterway, but that the indirect benefits from developing a commerce of 80 000 000 tons will more than repay the additional cost of a larger waterway. Such a result cannot be reasonably expected, and it is probable that 20 000 000 tons between the Lake ports and the seaboard is a much safer prediction; for, with the route closed one-third of the year, the railroads would certainly continue to carry a large part of the commerce.

The total traffic on the New York canals in 1898 was 3 360 063 tons, of which 1 573 227 tons were through freight. The total freight traffic over the New York Central Railroad was 23 403 439 tons, of which only 4 153 084 tons were through freight. The total freight tonnage on the New York State canals and railroads was 67 141 146 tons, of which probably about 15 000 000 tons were through commerce between the freight centers of the country tributary to the Lakes and the seaboard.

Mr. Wisner.

With a deep waterway completed and ready for business, it is probable that the railroads would still carry at least one-third of the through freight, leaving 10 000 000 tons available for waterway traffic.

It will not be safe to estimate that the through traffic will more than double in ten years after the completion of the waterway, indicating that 20 000 000 tons would be a maximum to be expected after ten years' operation of the waterway.

With an annual commerce of over 35 000 000 tons from the Lakes to the seaboard, the capacity of the waterway would have to be increased over that of the estimate of the Deep Waterway Board, which would materially add to the expense account of construction and maintenance.

The total entrances and clearances of New York Harbor are given by Mr. Corthell as 79 544 653 tons, from which it is evident that the actual export commerce from New York must be considerably less than the registered tonnage shown by the clearances of the port.

A safer estimate can be made by giving the port its proper percentage of the total exports of 29 000 000 gross tons from the entire country in 1899.

It is not fair to argue that because the deepening of the Lake channels from 16 to 21 ft. resulted in reducing freight rates 50%, that a deepening from 21 to 30 ft. will result in a corresponding decrease, for, as before stated, the economical dimensions of a freight carrier in waterways of unlimited depth is a function of the length of haul. The cost of ships, per ton of carrying capacity, increases rapidly with the dimensions of the ship, and the corresponding fixed charges increase faster than the saving in the cost of transport, and, therefore, where terminal detentions are large in comparison with the length of haul, the fixed charges from interest and insurance, in connection with the time of round trip, determine the maximum limit of economical construction.

With the Suez Canal the elements of the problem are entirely different. The vessels passing the canal make trips of several thousand miles, and, since the depth of canal is the controlling element for the entire trip, it will pay to increase the depth to 32.5 ft. with a traffic of only one-third of that of our Lake waterways, where, with a limited length of haul, 21 ft. seems to be an economical maximum depth for waterway improvement.

Referring to Mr. Monro's discussion, the writer by no means wishes to be understood as believing that the Canadian Canals will prove a failure only so far as they may be expected to divert traffic from the present lake and railroad lines, or to materially modify freight rates on such lines.

The Canadian Canals are achievements that their projectors may well be proud of, and in the future, as in the past, will continue to be

Mr. Wisner. important factors in the transportation of Canadian products and manufactures, which are almost certain to largely increase in the near future.

It is well known that barges of 10 ft. draft cannot safely navigate the Great Lakes except during the average quiet weather, and for this reason a barge canal capable of passing vessels of 16 ft. draft, or, say, 18 ft. deep, has been advocated.

Such a canal would shut out all traffic with the seaboard with the modern lake freighters, and, from the longer time required for passing fleets of barges through locks, would not have nearly as great a capacity as a 21-ft. canal. Such a canal would in no way aid in the development of ship construction on the Lakes, and, so far as the writer can see, would not produce any of the indirect benefits to be expected from a deeper waterway with large locks.

Observations to determine the relative speeds of large steamers in deep and shallow water and restricted channels have been continued since the writer's paper was written, with results which practically confirm those obtained by the Board of Engineers on Deep Waterways.

The observed speeds of five steamers running between known points on Lake Huron compared with those on Lake St. Clair, where the depth was only 2 to 3 ft. greater than the draft of the vessel, showed a reduction of speed of 16% in the shallow water. It should be remembered, however, that large steamers, with a speed of 10 miles per hour, run in a sort of trough produced by the motion of the boat and the action of the propeller, so that there is a "squat" of the ship of about 1 ft., making the depth of water beneath the keel that much less than indicated by actual draft of ship and depth of channel.

The observed speeds through the St. Clair Flats Canal and the restricted channels of the St. Mary's River show a little greater average than that obtained by the Board of Engineers on Deep Waterways, and indicate beyond question that 8 miles per hour is a perfectly safe speed in a waterway 21 ft. deep, and having a cross-section of 5 500 sq. ft.

Vol. XXVII. FEBRUARY, 1901. No. 2.

AMERICAN SOCIETY OF CIVIL ENGINEERS.

INSTITUTED 1852.

PAPERS AND DISCUSSIONS.

NOTE—This Society is not responsible. as a body, for the facts and opinions advanced in any of its publications.

THE KINZUA VIADUCT OF THE ERIE RAILROAD COMPANY.

Discussion.*

By Messrs. H. A. La Chicotte, Gustav Lindenthal and F. H. Cilley.

H. A. La Chicotte, M. Am. Soc. C. E.—The principal feature of this paper is the method of calculating the stresses in the structure, although if the title of a paper is an index of the contents, it is to the structure itself that the author would direct particular attention. That part of the paper devoted to a description and illustration of the work is so limited and devoid of detail as to necessitate going to outside sources for information relative to this structure sufficient to render an intelligent discussion of the subject possible. Fortunately, timely articles, appearing in recent issues of two technical journals, supply many of the necessary data which should have been given by the author. Mr. LaChicotte.

The reasons offered for adopting such a design as the author submits for criticism are by no means satisfactory, and it is to be hoped that discussion will bring out the relative merits of the several designs referred to, as well as a properly executed design of the articulated type. While the latter type was excluded from competition, it would no doubt possess advantages over that used, both in economy and rigidity. It is significant that the weight of the new structure should be nearly double that of the old, even after making due allowance for the increased traffic.

*Continued from January, 1901. See also November, 1900, *Proceedings*, for paper on this subject by C. R. Grimm, M. Am. Soc. C. E.

Mr. LaChicotte. The fact that the columns in a bent approach so nearly together at the top is of vital importance in the adopted design; and, without the verification of actual figures, the use of this type for a double-track structure would be precluded by reason of the greatly increased bending moments in the tower bents, and the resulting increased cost.

It is not necessary to state that the most suitable design for any structure is that which most nearly fulfills all the requirements of each particular case; and while allowance may reasonably be made for the personality of the designer, where matters of judgment and taste are involved, it is nevertheless incumbent upon him to adhere strictly to the principle of utility and suitability of design. This principle, when broadly interpreted, will be found to be amply elastic to cover all practical cases. Originality and fertility of resource are always commendable and usually valuable, but, unless guided by good judgment and practical common sense, are apt to lead to extremes. Neither prejudice against established forms, nor a liking for the unique may be allowed to dictate what a design should or should not be.

In the present case there are several details of construction open to criticism, and, while the speaker does not wish to be understood as condemning the design as a whole, there is nothing in the paper under discussion, nor in the requirements of the case, so far as known to him, which, in his opinion, would justify its adoption.

As to the analytical treatment for the determination of wind stresses, the author has presumed too much and left so much unexplained that to read the paper intelligently means to almost work out the problem on independent lines.

In fact, it was not until the speaker had worked out the problem for himself that he realized wherein lay the difficulty with the author's method.

Why the author felt justified in considering the columns as fixed at the base is past comprehension; and he is clearly in error in so doing. In the case of a one-story bent, not only is the base of the tower leg not fixed, but very much less fixed than the top, and the point of contraflexure in the column should be somewhat below the middle—that is, nearer to the smaller moment tending to fix the ends.

An incongruous result of the author's assumption and treatment is that the point of contraflexure is nearer the greater moment assumed as applied to the base of the column to insure its absolute fixity.

As a matter of fact, in applying the principle of least work, it should be made to cover the strut connecting the bases of the columns, as well as the other members of the bent, as little or no reliance can be placed in the anchor bolts as fixing the legs—especially on the expansion side of the tower.

The moments in the lower struts may always be expressed in terms of the moment of the adjacent column. If, in the expression for the

moment of the column, $M = P_5 z - X_5 (h + n z)$, z is put equal to a, there results, $M_a = 208.77 - 9.96\ X_5$, for the moment in the strut when the sign of M is changed. Mr. LaChicotte.

This moment divided by the half width of the tower base gives

$$X_4 = \frac{M}{i} = 20.96 - X_5.$$

Whence

$$\int M \frac{\delta M}{\delta X_5} dx = -\left[20.96 - X_5\right]_0^{x = 9.96} \frac{x^3}{3} = -6972.69 + 332.67\ X_5.$$

This result, divided by the moment of inertia of the strut, and added to the equation of condition already found for the other members of the bent gives,

$$\frac{36.06\ X_5}{107500} - \frac{26760.27 - 1758.54\ X_5}{10750} - \frac{6972.69 - 332.67\ X_5}{5511} = 0$$

Whence, $X_5 = 16.8$, $X_4 = 20.96 - X_5 = 4.16$.

The resulting moments (Fig. 12) on the bent are:

At top of Column $M_5 = 80.1$;

At base of Column $M_4 = 41.43$.

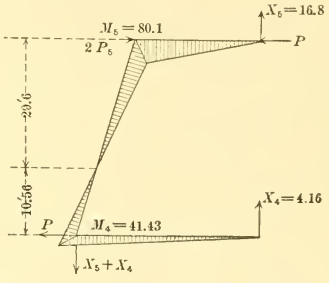


FIG. 12.

The point of contraflexure is located 20.6 ft. from the top of the column, or, about 5 ft. from the theoretical middle point assumed in the graphical solution.

Proceeding in a similar manner in the case of a two-story bent, the unknown force acting at the middle of the strut uniting the bases of the columns is found to be

$$X_3 = 34.363 - (X_5 + X_4),$$

the equation of moments $M = -[34.363 - (X_5 + X_4)]\ X$,

from which there results:

$$\int M \frac{\delta M}{\delta X_5} dx = -\left[(34.363 - [X_5 + X_4])\right]_0^{X = 20.3} \frac{X^3}{3} = -95\,820.49 + 2\,788.48\ (X_5 + X_4)$$

also,

$$\int M \frac{\delta M}{\delta X_4} dx = -\left[(34.363 - [X_5 + X_4])\right]_0^{X = 20.3} \frac{X^3}{3} = -95\,820.49 + 2\,788.48\ (X_5 + X_4).$$

These expressions, when divided by the moment of inertia of the lower strut, must be added to the equations of condition already

Mr. LaChicotte. found by the author. Performing the necessary operations, there result the following equations:

$$182\,930\ X_5 + 165\,309\ X_4 = 5\,400\,509;$$
$$25\,668\ X_5 + 26\,666\ X_4 = 797\,015.$$

Whence, $X_5 = 19.29$, and $X_4 = 11.3$;

also, $X_3 = 34\,363 - (X_5 + X_4 = 3.77$.

The resulting moments on the several members of the bent, as well as the positions of the points of contraflexure, are shown in Fig. 13.

These results do not differ materially from those of the author, but the resulting moments on the columns are uniformly greater at the top and less at the base, owing to the less degree of fixity at the base than was assumed by the author. It is noticeable also that the point of contraflexure in the upper column of a two-story bent is considerably lower (nearly 6 ft.) than in a one-story bent.

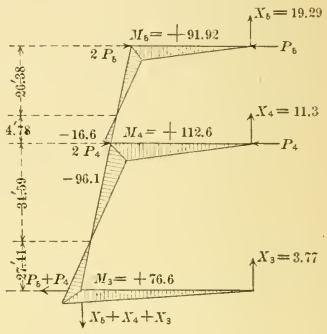


Fig. 13.

The position of the point of contraflexure depends upon the relative fixity of the ends of the individual member.

Owing to the symmetry of the bent, the ends of the struts are equally fixed, and the points of contraflexure are at their middles. The ends of the columns, however, are not equally fixed, as a rule, and the points of contraflexure will be found nearer the smaller moment.

If the struts at the bases of all the smaller towers are those used at the corresponding panel points of the large tower, counting from the top, no very serious errors will be found in the stresses of the smaller towers; but if, as in the case of the large tower, the bottom struts have been made slender as compared with those above, the resulting stresses, when these struts are included in the system, will be found to differ substantially from those given by the author.

The erroneous assumption of fixity at the base of the columns, and the failure to extend the calculations to the bottom struts, have led to serious errors in the large tower.

Here, the bottom strut has a moment of inertia of 2 216 quad. ins., while the half length is 51.02 ft. The moment at the base of the column is:

$$2\,704.892 - 51.02\ (X_5 + X_4 + X_3 + X_2 + X_1 + X_0)$$

whence, $X_0 = \dfrac{2\,704.892 - 51.02\ (X_5 + X_4 + X_3 + X_2 + X_1)}{51.02}$

which must be taken negatively, since it produces a left-hand or negative moment; hence, Mr. LaChicotte.

$$-X_0 = -53.016307 + (X_5 + X_4 + X_3 + X_2 + X_1) \ldots\ldots\ldots\ldots (a)$$

$$M = -X_0 x, \quad \frac{\delta M}{\delta X_0} = -x, \quad \int_0^{x=51.02} M \frac{\delta M}{\delta X_0} \delta x = 44\,269\, X_0.$$

Substituting the value of X_0 from (a) there results:

$$\int_0^{x=51.02} M \frac{\delta M}{\delta X_0} \delta x = -2\,346\,979 + 44\,269\,(X_5 + X_4 + X_3 + X_2 + X_1)$$

The value of this integral, when divided by the moment of inertia of the lower strut, must be added to each equation of condition. Multiplying each equation by 107 500, the value of the largest moment of inertia, and grouping the values of X_5, X_4, X_3, etc., there result the following five equations, containing five unknown quantities:

$$4\,530\,396\, X_5 + 4\,512\,770\, X_4 + 4\,365\,420\, X_3 + 3\,957\,800\, X_2 + 3\,361\,799\, X_1 = 222\,736\,629.$$
$$4\,512\,770\, X_5 + 4\,519\,221\, X_4 + 4\,365\,420\, X_3 + 3\,957\,800\, X_2 + 3\,261\,799\, X_1 = 222\,469\,029.$$
$$4\,365\,420\, X_5 + 4\,365\,420\, X_4 + 4\,383\,375\, X_3 + 3\,957\,800\, X_2 + 3\,261\,799\, X_1 = 217\,953\,209.$$
$$3\,957\,800\, X_5 + 3\,957\,800\, X_4 + 3\,957\,800\, X_3 + 3\,989\,471\, X_2 + 3\,261\,799\, X_1 = 202\,011\,089.$$
$$3\,251\,799\, X_5 + 3\,261\,799\, X_4 + 3\,261\,799\, X_3 + 3\,261\,799\, X_2 + 3\,318\,056\, X_1 = 170\,430\,318.$$

The values of the unknown quantities resulting are, $X_5 = 19.454$, $X_4 = 11.673$, $X_3 = 8.138$, $X_2 = 6.494$, $X_1 = 6.528$.

The value of X_0 is found from Equation (a), and is $X_0 = 0.729$.

The resulting moment, and positions of the points of contraflexure, are shown in Fig. 14, the notation of the author having been followed, in order to facilitate comparison with the results given by him. The effect of the author's assumption is strikingly illustrated in the case of the columns of the first story where the moments at the top are increased about 70%, and in Strut No. 1 where there is an increase in the moment of about 32 per cent.

It is to be noticed also that the point of contraflexure in the column of the first story is to be found about 20 ft. below the middle point, while the moments given by the author show it about 4 ft. above the middle. This illustrates the danger of arbitrary assumptions as a basis of computations, and points clearly to the duty of using simple determinate forms unless conditions are such as to require otherwise.

The increased moments in the first story will run the unit stresses considerably above the limits fixed by the author, and would seem to necessitate the use of diagonal rods, or lower struts of greatly increased moments of inertia, to correct the evil.

It will probably be noticed that while the author has expressed the moments in foot-tons, the moments of inertia of the several members have been expressed in quad. inches. This is a very fruitful source of

Mr. LaChicotte. error in ordinary computations of deflections, but in the present case no error results because it is the relative and not the actual values of the several moments of inertia which affect the results.

The work of deformation in a truss or beam may be produced by a moment, direct stress, shear or torsion, in any combination, depending upon the manner of application of the external forces.

In ordinary bridges torsion is avoided or reduced to a minimum; so that its effect may generally be neglected. In trusses the shear is usually replaced by direct or axial stresses, and in beams the work of deformation due to shear is very small as compared with that due to direct stress or bending; so that the effect of shear, as such, may usually be neglected without sensible error.

Under ordinary conditions, the only forces that need be considered as producing deformation are those of bending and direct stress; so that the work of deformation, which must be a minimum, may generally be expressed by the formula

$$W = \int \frac{M^2\, dx}{2\, E\, I} + \int \frac{P^2\, dx}{2\, E\, A} = \text{Min.}$$

Where M = the moment of the external forces;
E = the modulus of elasticity;
I = the moment of inertia of the section;
P = the axial or direct stress acting upon the section whose area is A;
and dx = the element of length.

It is a matter of common knowledge that a force acting on a bridge member of ordinary proportions will distort it much more by bending than by either direct tension or compression, and it requires more material to resist the action of bending than that of direct stress. This is but another way of saying that the work of deformation of an axial force is very small as compared with that of a moment, and the author properly recognized this fact in dropping from the foregoing equation the expression for the work of the direct stresses; reducing the equation to the form

$$W = \int \frac{M^2\, dx}{2\, E\, I} = \text{Min.}$$

But in so doing he must have realized fully that by omitting the diagonal bracing of the towers it became necessary to introduce into the tower legs to resist the bending, a sectional area many times that of the discarded diagonals. Nearly one-half the sectional area of the tower legs is required to resist bending, while a small part of this additional area would suffice for an effective system of diagonal rods.

The writer fully realizes that the lighter structure is not necessarily the cheaper, as there are many other considerations besides that of weight of material. Facility of erection is important, but the data

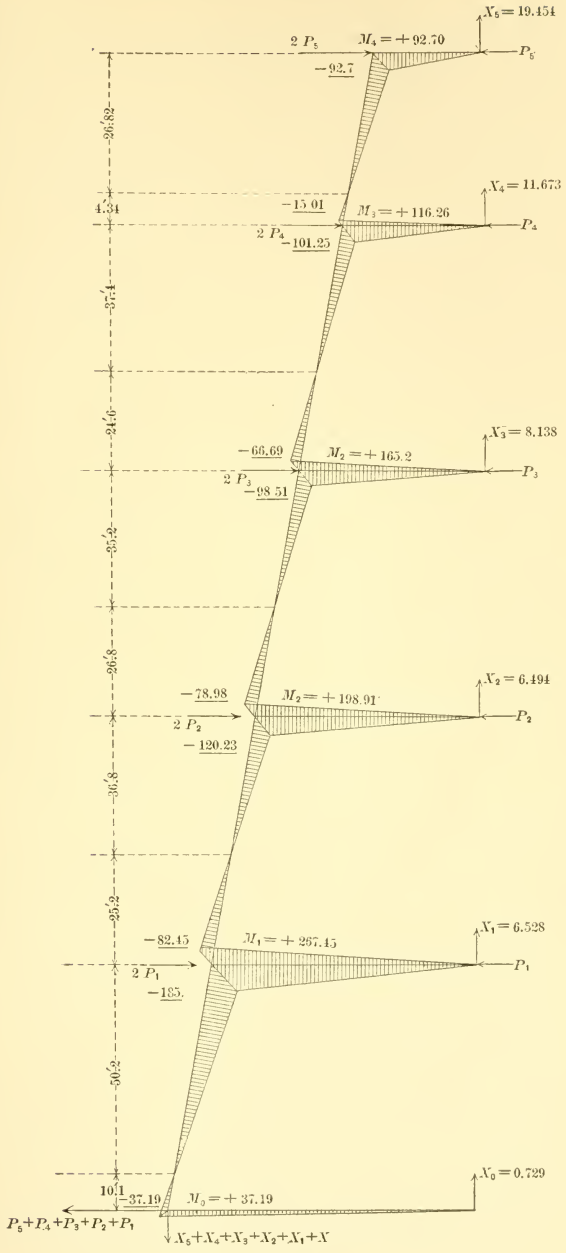

$X_5 = 19.454$
2 P_5
$M_4 = +92.70$
P_5
−92.7
26.82
$X_4 = 11.673$
4.34
−15.01
$M_3 = +116.26$
P_4
2 P_4
−101.25
37.4
24.6
$X_3 = 8.138$
−66.69
$M_2 = +165.2$
2 P_3
P_3
−98.51
35.2
26.8
$X_2 = 6.494$
−78.98
$M_2 = +198.91$
2 P_2
P_2
−120.23
36.8
25.2
$X_1 = 6.528$
−82.45
$M_1 = +267.45$
2 P_1
P_1
−185.
50.2
$X_0 = 0.729$
10.1
−37.19
$M_0 = +37.19$
$P_5+P_4+P_3+P_2+P_1$
$X_5+X_4+X_3+X_2+X_1+X$

FIG. 14.

Mr. LaChicotte. given by the author do not point to undue economy in this respect, even after allowing for the removal of the old structure. Uniformity of details has an important bearing upon the cost, both of manufacture and erection; but uniformity is very often secured by too great a sacrifice of material, and the ultimate cost of the structure thereby increased rather than reduced. If the contractors furnished the work in this instance at a pound rate, they are to be congratulated for devising a type of structure involving a minimum shop cost and a maximum tonnage.

Mr. Lindenthal. GUSTAV LINDENTHAL, M. Am. Soc. C. E. (by letter).—The first Kinzua Railroad Viaduct (built of wrought iron) attracted world-wide attention from engineers at the time of its construction (1880–81), because of its great height and the rapidity of its erection. Its articulated design of short spans—expansion joints at every tower, and the towers made up of braced bents, which were subject to large bending strains in the direction of the track—was not favorably thought of at that time by some engineers, who believed that the rigidity and durability of the viaduct were impaired thereby. Experience has proved the prediction to be correct. It is well known that, almost from the beginning, trains over that structure were obliged to slow down to about 5 miles per hour. Even then the vibrations, although not dangerous, caused unpleasant sensations.

The old structure was typical of the American form, as distinguished from the European form, of metallic viaducts. In the latter the aim was always to obtain great rigidity, so that trains could pass over them without diminution of speed. Compact towers, continuous girders and longer spans were the leading features. Long-span arches also occur as parts of such viaducts over deep ravines, as in the Garabit Viaduct, in France, and the Münster Viaduct, in Germany.

It is a singular fact that in American bridge specifications, up to this date, as far as known to the writer, there are no provisions insisting upon rigidity of structure. If obtained, it is accidental, or the result of extra provisional care by the designing engineer, which he is under no obligation to give. The old Kinzua Viaduct complied in all respects with the old Erie specifications, which were then considered among the best. Nevertheless, it was a swaying structure, unfit for trains at ordinary speeds, and inferior to similar structures in Europe, built ten and twenty years earlier.

Among the earliest was the well-known double-track viaduct at Freiburg, in Switzerland (built in 1862), about 225 ft. high and 1 100 ft. long. The Iglava Viaduct, in Austria, the Ossingen Viaduct, in Switzerland, and others of considerable height and length, followed the Freiburg example. Faulty as some of their details are, in the light of present engineering knowledge, the essential fact remains that even at that early day it was found practicable to build high iron viaducts

of sufficient rigidity to carry trains without diminution of speed. The weight of locomotives and cars on these viaducts since then has also increased, but they have stood wear and tear very well, and, so far as known, will, with few repairs, be serviceable yet for a number of years. Mr. Lindenthal.

In the American construction, greater importance was attached to the temporary advantage of rapid erection, without falseworks, and with the fewest men, far away from the bridge shops. It led to type of thin-legged and short-span trestle structures of flimsy appearance, inferior in rigidity to the European type. The trestle type may answer well enough for low heights, but is not suitable for greater heights, as proven by the old Kinzua Viaduct, and by a few other American railroad viaducts of less height which could be named.

The weight of locomotives and cars on the Erie Railroad has nearly doubled in the last twenty years, and the viaduct might have had to be rebuilt in any case; but, in doing so, the time had arrived also for a rigid structure over which trains could be run at full speeds. This should have been the leading thought in the new design. It appears from this paper, and from the character of the plans, that such was not the case.

Because rolling stock has doubled in weight in the last twenty years, it does not follow that it will double again in the future. The limit will soon be reached (by reason of the crushing strength of hard steel in rails and wheel tires). An increase of 50% in the weight of the present heaviest rolling stock is improbable. But if it should occur, that margin is amply covered by the working stresses of the present Erie specifications. The new structure, under these conditions, should have been designed to be a permanent one, to last centuries.

For an intelligent judgment of the plans, Mr. Grimm does not furnish sufficient data. There is, for instance, no elevation or diagram of the viaduct, showing the arrangement and location of the expansion joints. The description of them on page 1070* is not intelligible without such elevation. No weights of the new structure are given, from which the economy of design could be judged, in view of the author's allegation that the choice of the peculiar system of wind bracing in the towers was prompted by economy, when compared with other systems of bracing. Neither are data given as to the behavior of the structure under trains.

Some remarkable assumptions have been made. For instance, below the diagram (Fig. 8), showing the stresses in the tower bracing from breaking, is a note as follows:

"The computation of the stresses from the braking of trains assumes the point of contraflexure at half the height of the towers."

* *Proceedings*, Am. Soc. C. E., for November, 1900.

Mr. Lindenthal.

From which it appears that the towers are assumed to have at the top bending moments of the same value as those at the bottom, where the tower legs are anchored. How these are possible with the shallow plate girders of the superstructure (of different heights and discontinuous chords) requires an explanation.

The horizontal force from a braking train per tower is not stated on the diagram, but may be judged, from the strains given for the stiff web members, to be about 50 000 lbs. for one side, or 50 tons per tower. For prudential reasons, the entire height of the tower, and not half its height, must be taken as the leverage for that force. The placing of an expansion joint in the superstructure at every third or fifth tower has not the slightest influence on that condition. The bending moments at the base will, therefore, be double those assumed; and there can be no bending moments at the top of the towers worth considering. Whether the columns and anchorages at the foot of the high towers are sufficiently strong to resist those larger bending moments cannot be judged from the meager data in the paper.

There are the further questions: How much do the towers bend or deflect under the horizontal braking force applied at the top? And does not the bending of the towers subject the riveted connections (of the track girders) at their tops to large bending strains, for which these connections are not adapted? Would not the high towers bend so much under a suddenly braked train as to cause the girders to slip off the roller bearings at the expansion joints, and cause the viaduct to collapse? Is not the only safety against such an occurrence in the continuity of the track structure?

These important questions can be accurately answered only with the aid of deflection diagrams of the towers, which are not given.

The most characteristic feature of the towers, however, is in the peculiar lateral bracing, called ordinarily the wind bracing, because (except on curves) it is usually dimensioned only for wind pressure, assumed to act quiescently. But the fact cannot be overlooked that this bracing is also exposed to the lateral impact and vibrations generated by the moving trains. These strains are dynamic in their nature, and therefore more dangerous on that account. The impact and vibration increase as the square of the train speed. Every trackman knows from experience that on a shaky structure trains must run slowly, although he may not know the theoretical reasons for that necessity.

Most bridge specifications make allowance for vertical impact by the addition of arbitrary percentages to the train-loads. A similar allowance should be made for horizontal impact, for the lateral vibration of fast moving trains, and for the violently alternating strains on the bracing. In ordinary bridges, these strains may safely enough be assumed to be included in the wind strains; but in high viaducts, or long spans, such an assumption is not warranted by observed facts.

Mr. Lindenthal.

In the new Kinzua Viaduct, the lateral bracing is without diagonals in the towers. Stiff gusset connections with the horizontal braces take their place, on the plea that they are more economical. This may well be doubted. Does that arrangement produce a more rigid construction laterally? It is obvious that a deflection diagram of the tower bents at right angles to the track would furnish the emphatic answer "No."

Higher mathematics, as applied to the principle of least work, was probably never used for a poorer purpose than in the calculation of this tower bracing, needlessly made to be statically indeterminate, and which is inferior to the statically determinate bracing in the old towers, unsubstantial as the latter had been. The whole procedure shows a misconception of the fundamental conditions of good designing, and theoretical trifling with a serious problem, involving the safety of the structure.

Its details are also open to question. For instance, the large shearing strains in the tower columns from the bending moments at the gusset connections are taken up by the lacing angles. The single shear rivets of these angles, therefore, have to resist strains additional to those of ordinary lacing. The alternating strains from the horizontal impact and vibration expose the lacing angles to a sawing action. There is great likelihood here of the rivets loosening and endangering the stability of the towers. By turning the columns one-quarter around, so that the solid web plates would have taken the shearing strains, that danger, at least from loose rivets, would have been avoided.

But, after all, the defects in the bracing may be readily cured by the insertion of additional triangular or diagonal braces. The necessity for them in the higher towers will arise sooner or later.

If the new viaduct should seem at present to be stiffer than the old one, it can be so only on the low bents and under slow trains, and by reason of the greater weight and bulk of the new structure.

A rigid viaduct does not necessarily mean a more expensive one. Expansion joints should be the fewest in number. The structure is only about 2 000 ft. long, and dilatation joints placed at each end of the viaduct would have been sufficient to take care of temperature changes. The towers should not be subjected to the heavy strains from braking trains; they are not adapted for them. Resistance to braking trains can be furnished without them. Looseness of structure, lengthwise with the track, was a potent cause of the shakiness of the old structure.

If a competition of designs and bids had been invited, on the condition that the new structure must be suitable for fast trains, and that the sudden braking, or the starting up, of a double-header train must in no wise endanger its safety, then the proof would most likely have

Mr. Lindenthal. been furnished, in a variety of designs, of its being readily attainable, and at no greater cost (if as great) than the structure described in this paper.

Mr. Cilley. F. H. Cilley, Esq. (by letter).—This paper raises many most interesting questions, both theoretical and practical.

For the calculations, Mr. Grimm gives preference to an application of what is known as "the principle of least work," a principle so little known and less understood, even by many who use it, that a brief examination and exposition of it here may be of interest.

As commonly stated, this principle declares that "the actual stresses in a structure are those which make its work of deformation a minimum." But, set forth in these terms, the principle is in several ways most misleading when not actually incorrect. It suggests that it is based on the popularly accepted law that all natural processes tend to pursue the course most economical of energy. Yet, as this latter is not a true law, the principle, in so far as it is correct, cannot be simply a special application of it.

If one sought to interpret the law, ignorant of the rules for its application, one's impression would probably be that it asserted that the actual stresses (which are, of course, in equilibrium) represented less stored energy than any other set of stresses (not balanced and therefore momentary), that is, that it asserted that the energy of the frame in the state of equilibrium under given forces was less than in any non-equilibrated state under these forces—a law of dynamics.

But, actually, it in no way states conditions of equilibrium, and is not a law of dynamics. What it really asserts is that the set of stresses in equilibrium under the given applied forces, which would wholly disappear on the removal of those forces (that is, which would occur under the applied forces if there were no initial stress), is that one among all possible sets of stresses in equilibrium under the given applied forces (for there are numberless such sets for all indeterminate structures), for which the potential energy of the structure is least. And the reason for this fact is of the simplest. For structures obeying Hooke's law, the distortion accompanying the application of any given set of forces is independent of the existence of initial stress, and, therefore, not only the change in stress, but the work done to the structure by the applied forces, and, therefore, the change in the potential energy of the structure, are independent of the existence of initial stress. Thus, the total potential energy of a structure in equilibrium under given applied forces is its initial potential energy (due to its initial stresses) plus the (invariable) change of potential energy due to the application of the given forces. The total potential energy evidently is least when the initial potential energy is zero, that is, when there is no initial stress, and thence the law as last

stated. It is not a law of equilibrium; it is not a special case of a great universal law of Nature, but is simply a limited law of the theory of elasticity, dependent for its truth, even in the second form given herein, on whether Hooke's law happens to hold, or does not happen to hold, for the materials and manner of distortion of the structure under consideration. In its first form it is not necessarily correct, even where Hook's law does hold, for the stresses it determines are, in general, simply the changes in stress due to the gives applied forces, which are only the actual stresses when there chances to be no initial or self-balancing stresses. Mr. Cilley.

Now, as to its application: First, the potential energy of the structure under the given applied forces must be expressed in terms of any variable set of stresses in equilibrium with them, and including in their variation the set of stresses sought. This is done by noting how many more stresses have to be determined than there are conditions provided by statics. As many of the stresses as have thus been found to be in excess are then designated by letters as unknowns. They evidently may be independently given any arbitrary values whatever, and the conditions provided by statics still be satisfied. They are, therefore, independent variables. The conditions of statics now permit all the stresses in the structure to be expressed in terms of the applied forces and these unknown stresses. Thence it is very easy to express the corresponding potential energy of the structure. Now, for the solution sought, the set of stresses for which there is no initial stress, or the change in stress under the applied forces—the set of values of the unknowns—the independent variables—must be found, which will make the expression for the potential energy of the structure a minimum. This is purely a question of mathematics. As is known, the differential coefficient of the expression for the potential energy of the structure, with respect to each of the independent variables, must be zero. This gives as many equations as there are independent variables. Stress being proportional to strain (Hooke's law), the expression for the potential energy of the structure is quadratic in terms of the variables. These partial differential coefficients are therefore linear. The values of the independent variables, consequently, are determined simply by solution of linear equations. Such is, in outline, the complete explanation of "the principle of least work" and its application.

What are its merits and demerits as a working method? it may be asked.

It may be used almost mechanically, and therefore saves thought, but at the expense of understanding. Like most integral theorems, it is a sort of blanket which hides the details and prevents the perception of the significance and purpose of the procedure. On this account, the writer is inclined to prefer the use of a more objective

Mr. Cilley. method, in which the structure is conceived as being so cut up or otherwise altered as to make it statically determined, place forces and moments at the various cut sections or otherwise altered points to replace the restraints removed, then, preferably, by aid of the method of virtual work (also known as the method of virtual velocities or displacements), determine the corresponding displacements, the equation of which gives the conditions which must exist in the original uncut and unaltered structure. In the case of no initial stress this results in precisely the same linear equations as before, * but here the meaning of each is clear; one is in close touch with the physical problem at all times; errors are easily discovered and corrected; the consequences of changes are readily perceived, and one gains a really intimate insight into the workings of the structure which is the object of the investigations. In particular, cases involving consideration of changes in temperature, yielding supports, errors in workmanship, and initial stresses generally, are dealt with clearly and readily.

Turning from general considerations to the special problem offered by the design of the Kinzua Viaduct, consider the plane bent of five stories. By cutting through each of the five headers, say at the middle, separating the two halves and putting at each cut section the forces which had actually acted on it before the cutting, each of the halves would become statically determinate, and would offer no further difficulties. But these forces acting on the cut sections are precisely those which are not known, but have to be determined. At each section there are three of these, a shear, an axial stress and a moment, or fifteen in all. Indicating each of these by a letter, there would be no difficulty in writing out the expression for the potential energy of the whole bent in terms of the applied forces and these fifteen unknowns. Partially differentiating with respect to each of these unknowns, and placing each result equal to zero, fifteen linear equations between the fifteen unknowns are obtained, the solution of which yields their values.

But in Mr. Grimm's treatment not fifteen but only five unknowns appear, and only five equations are found. This is in consequence of

* The potential energy of a structure under load may be expressed by $\frac{1}{2}\sum S\Delta$ — one-half the sum of all the products of the stresses into the corresponding strains—if the material obeys Hooke's law. The strains Δ are proportional to the stresses S, $-\Delta = KS$ say—so that the potential energy of the structure becomes $\frac{1}{2}\sum KS^2$. Now, if the structure be statically indeterminate, the S are linear functions of the superabundant stresses X. The values of these, if there are to be no initial stresses, it has been seen, must satisfy the equations obtained by the partially differentiating the energy equation, $\frac{1}{2}\sum KS^2$, with respect to each of them, bearing in mind that they are independent variables, and equating each result to zero. That is, the X are determined by solution of the simultaneous linear equations: $\frac{\delta\,(\frac{1}{2}\sum KS^2)}{\delta X} = \sum KS\frac{\delta S}{\delta X} = 0$.

But the expressions $\frac{\delta S}{\delta X}$ are the stresses S^1 which would result, if the value unity were given to the X in question, all other X being zero, and the equations become: $\sum KSS^1 = 0 = \sum \Delta S^1$; a form familiar to all who use the method of virtual work, which at once expresses the fact that the difference in displacement in the direction of X of the two sides of the section on which the stress X works, is zero.

his neglect of certain factors. If the complete equations were written out, denoting by Y and Z the axial stress and central moment, respectively, of each header, it would be found that, owing to the symmetry of the structure and the character of the loading, the equations $\frac{\delta F}{\delta X} = 0$ do not contain either the Y or the Z, while the equations $\frac{\delta F}{\delta Y} = 0$ and $\frac{\delta F}{\delta Z} = 0$ do not contain the X; F representing the expression for the potential energy of the bent under the given loading. Mr. Grimm considers only the first set of equations. The second and third sets determine values of Y and Z largely dependent on the compressibility of the headers. Assuming the headers incompressible (although flexible) the Y and Z become zero, and this, at least, is involved in Mr. Grimm's solution. He further treats the columns as incompressible and inextensible, although flexible. Mr. Grimm's statements in this connection on page 1075* are very misleading. Mr. Cilley.

Turning to Mr. Grimm's actual work, it may be noted that he has integrated for the vertical distance between headers, instead of for the true oblique lengths of the columns. These and other errors in his work, made apparent by a calculation of the deflections from his results, which wholly failed to check, made it futile to attempt any thorough discussion of Mr. Grimm's design from his own data, and the computation of correct data is too laborious.

On two points, however, it is important to arrive at some sort of a conclusion: As to the economic necessity of the design used, and as to its stiffness.

As to the first of these, the writer finds that by Mr. Grimm's data the unit stress in the headers rises to some 12 000 lbs. Taking this as a basis, and the column formula as published, the writer computed a stiff system of diagonal bracing at about 45° with the vertical, and found it at least as light as the headers. So that, even without considering the removal of the secondary stresses in the columns (some 5 000 lbs. per square inch) resulting from the use of the stiff diagonal system, it is at least as economical as that actually used, thus showing that Mr. Grimm was mistaken in supposing his design one required for economy.

As to the second, it apparently does not require argument to demonstrate that a completely braced frame must have smaller deflections for the same unit stresses than a frame without diagonals, resisting only through the bending of relatively slender members. Mr. Grimm, at least, can hardly take exception to this conclusion in this case, for in his work he has gone on the basis that the distortions due to bending are so great that those due to axial stress are by comparison wholly negligible. Either this is correct or Mr. Grimm's computations are worthless.

* *Proceedings*, Am. Soc. C. E., for November, 1900.

AMERICAN SOCIETY OF CIVIL ENGINEERS.

INSTITUTED 1852.

PAPERS AND DISCUSSIONS.

NOTE.—This Society is not responsible, as a body, for the facts and opinions advanced in any of its publications.

A DIRECT METHOD OF SPACING RIVETS AND FINDING THE POSITION, ETC., OF STIFFENERS IN PLATE GIRDERS.

Discussion.*

By Messrs. H. A. La Chicotte, O. F. Nichols, F. D. Rhodes, Ernst F. Jonson and E. Schmitt.

Mr. LaChicotte.

H. A. La Chicotte, M. Am. Soc. C. E.—The author has suggested a graphical method of spacing rivets in plate girders, which is really a graphical solution of a well-known formula:

$$p = \frac{v\,h}{s}$$

in which p = the pitch;
v = the rivet value;
h = the depth of girder between rivet lines;
and s = the shear, assumed as more or less uniformly distributed over the section.

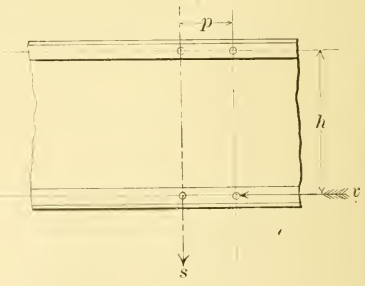


FIG. 9.

Fig. 9 will indicate clearly the derivation of the formula by the method of moments.

According to the common theory of the plate girder, the lines of stress in the web act at an angle of 45° with the vertical, so that the stress induced in the flanges by the web must, in a length of flange

* Continued from January, 1901. See November, 1900, *Proceedings*, for paper on this subject by E. Schmitt, Assoc. M. Am. Soc. C. E.

equal to the depth of the girder, equal the shear. In other words, there must be enough rivets in either flange, within a length equal to the depth of the girder, to equal the shear. Mr. LaChicotte.

If, in addition to the horizontal stress in the flanges, the rivets are required to transmit to the web a local load, Q, more or less distributed and acting at right angles to the flange stress, the rivets must be spaced to resist the resultant of the two stresses.

If Q be distributed over a distance k (less than h), the diagonal lines of stress distribute it over an equal distance in the vertical section of the web, and, in order to distribute it with equal intensity over the whole section, Q must be first divided by k to find the unit intensity, and then multiplied by h, or, $\frac{Q\,h}{k}$. The formula for pitch now becomes:

$$p = \frac{v\,h}{\sqrt{s^2 + \left(\frac{Q\,h}{k}\right)^2}}.$$

If the load Q be distributed over a distance equal to h,

$$p = \frac{v\,h}{\sqrt{s^2 + Q^2}}.$$

The application of the formula $p = \frac{r\,h}{s}$ is very simple, after the shear has been computed at the requisite number of points; and, knowing the law of change in the shear, the desired results are quite as quickly obtained by the analytical as by the graphical method. For any particular girder, s being the only variable, the values of p, for any number of points corresponding to known values of s, may all be read from a slide rule by a single setting.

If the stresses in the girders are found graphically, the author's method of spacing rivets is a valuable adjunct, but if these stresses are determined analytically, the time and labor of constructing the diagrams for spacing the rivets graphically would be much greater than in the analytical solution of the problem.

If any of the foregoing equations be transformed and solved for v, the resulting value for Maximum $s \times$ Minimum p determines the necessary thickness of web when reference is made to a table of rivet values for any particular size of rivet.

As to rivet spacing in stiffeners, these formulas may or may not apply. If they apply, it is necessary to assume that the stiffeners act as columns, and this, at least, is a moot question. To illustrate, imagine a number of planks piled on edge one upon another; unless supported laterally, they would not stand alone, much less carry a load imposed upon them; but, if posts directly opposite each other be placed on each side, in contact with the planks but not attached to them, a con-

Mr. LaChicotte. siderable load would be sustained by the planks, although receiving little assistance from the posts. This seems to show that the office of the stiffener is not to take stress, but to enable or compel the web to do so; and, for that reason, only a few rivets are needed in the stiffeners to properly hold them together. As usually constructed, there is no doubt that the stiffeners act with the web and serve to disturb and complicate the theoretical lines of stress, but there is no reason for assuming that because they take some stress they must take all over and above the buckling value of the web.

The foregoing reasoning applies specially to intermediate stiffeners, which do not serve to convey any external load to the web.

In the case of concentrated loads brought to the web from transverse floor beams, or more or less distributed on either flange of the girder, the stiffeners must be proportioned to convey these loads to the web, but in each of these cases practical considerations of construction will usually determine the size of stiffeners.

At the ends of the girder the lines of stress being cut, the web has little buckling value, and the stiffeners must be proportioned to convey practically the whole shear to the support. The stress in the end stiffeners due to shear varies practically from zero at the top to about the full amount of the shear at the bottom, and there must be rivets enough to convey this shear from the web to the stiffeners. A girder properly stiffened at the ends and at points of local concentrated loads will usually need very little intermediate stiffening.

The author suggests figuring stiffeners as flat-ended columns, and the questions naturally arise: Upon what will these columns rest? If on the bottom flange, how can rivets enough be grouped in the flange at the base of the stiffeners to convey the reaction of the column from the flange to the web? And why should the shear follow the roundabout path through stiffeners and flanges?

The author refers to a well-known formula for finding the buckling values of webs, and advocates the spacing of stiffeners about the depth of the girder apart whenever the shear in the web equals or exceeds the value of w in the formula

$$w = \frac{10\,000,}{1 + \frac{b^2}{3\,000\,t^2}}$$

This method of spacing stiffeners, while quite common, is not consistent, for the reason that this formula pretends to give the buckling value of the web, but does not express the relation of this value to the shear.

If the web needs stiffening at all, why not in some proportion to the shear? If the foregoing formula be applicable at all, it should be made to express the actual relation between load and column length

by substituting "shear" for "w," and solving for h, whence results for the distance between stiffeners or flange angles, Mr. LaChicotte.

$$h = \sqrt{\frac{30\,000\,000\,t^2}{\text{shear}} - 3\,000\,t^2};$$

When h is more than the depth of girder, no stiffeners are required, except for local concentrated loads.

The common practice of stiffening plate girders at distances apart of about the depth of the girders, is probably far on the side of safety; but it would, nevertheless, be unwise to depart materially therefrom, until a more rational method has been devised.

In regard to determining the size of stiffeners necessary to prevent the web from buckling, it may be said that no rational method of figuring the stresses in the webs of plate girders has yet been devised, and therefore no exact determination of the size of stiffeners is possible.

It is useless to say that if the web maintained its plane form, no stiffeners would be required; but the webs are not perfect planes, having many bulges or buckles of more or less magnitude as they come from the mills, and which buckles cannot always be detected or removed in the process of manufacture of the girder.

It may safely be said that stiffening angles large enough to accommodate the rivets and conform to the usual shop practice will prevent the web from buckling. Of course, the end stiffeners, as well as those at points of local concentrated loads, may be larger than elsewhere; and, perhaps, the most that can be said is that good judgment based on present practice will usually be a safe guide in special cases.

O. F. Nichols, M. Am. Soc. C. E.—The speaker admits with candor, and with pride, that so far as he has had anything to do with plate girders, he has followed the teachings and experience of Theodore Cooper, M. Am. Soc. C. E., who taught that in order to get more rivets safely into the flange angles, and to devolop fully the efficiency of these angles, their depth should be increased so as to carry at least two rows of rivets wherever many rivets were required. This has a double advantage: The rivets need not be spaced dangerously near together, and the deeper angles confine all the elemental portions of the web, so that, considering them as columns, they are practically fixed at the ends, and, consequently, are better able to sustain the loads imposed. Mr. Nichols.

The Pennsylvania practice has been very largely followed in this country and elsewhere. A good deal of the misunderstanding about stiffeners in plate girders is probably caused by following the Pennsylvania standard too closely. An interesting experiment was made by one of the Pennsylvania engineers: He constructed a model girder, from paper, then, after cutting the web on diagonal lines at 45° in

Mr. Nichols. one direction between the stiffeners, spaced at equal intervals about equal to the depth of the girder, the girder was put under stress. He found that the stiffeners took the vertical load, and that the elements of the web buckled under compression and remained straight under tension. Of course, cutting the web in that manner converted the model girder into a sort of Pratt truss, and the conclusion drawn, that stiffeners were necessary at intervals equal to the depth of the girder, was quite a logical sequence from the premises.

The more rational method, and that more closely followed in recent times, is to consider plate girders as acting very much as lattice girders act. Take a case in which the girder web is not stiffened; then, if it is regarded as a lattice girder, there is an infinite number of intersections, and if it be assumed that the stresses pass in diagonal lines through the web, in both directions, while the compression would tend to buckle the web, the tension along the other lines at right angles would tend to keep it straight. As a matter of fact, in all tests of plate girders, it is found that there is a remarkable and an unaccountable degree of stiffness in the unsupported web.

Mr. LaChicotte is right in stating that, if there are rivets enough in the stiffeners to prevent them from buckling out, it is all that can be required. Fitting them against the flanges is not necessary, unless, as he has said, the top of the girder is to sustain the load; in which case, of course, there must be a close fit, at least against the top angles.

There has been a great misuse of stiffeners. In some elevated railroad structures, for example, where the uniform loads are relatively low, and where the girder is often very shallow, a $\frac{3}{8}$-in. web is generally used with a multitude of stiffeners. In quite ordinary practice the angle is used as a stiffener, and is often placed with its back toward the middle of the girder. At the middle of the girder, either for symmetry or from a desire to be strictly impartial between the two ends of the girder, two stiffeners are placed, back to back, where none is needed. These structures have generally been built by the pound, on designs by the contractors, and in such cases this excess of stiffeners has an advantage not easily overlooked. Some ten years ago, several miles of elevated structure were built in which, by deepening the standard girder about 15% and omitting stiffeners, the average strength was increased and the weight diminished nearly 20 per cent. Of this structure, a leading bridge expert, recently engaged by new owners to report on its strength, said: "The bold omission of these (stiffeners) has apparently worked all right in practice, and secured a substantial economy of metal."

Of late years there has been a most exemplary attempt to avoid serious errors in the use of stiffeners; to rely, indeed, almost entirely on the web itself, unaided by stiffeners; and now it is the exception,

rather than the rule, to find stiffeners in stringers on large bridges, Mr. Nichols.
although they carry very heavy loads and are subject to varying stresses, of impact, etc. In the Buffalo Trace Viaduct, designed by Edwin Thacher, M. Am. Soc. C. E., some ten or twelve years ago, the longer girders are about 60 ft. in length and approximate 5 ft. in depth. The viaduct carries a standard-gauge railroad, and no stiffeners whatever are used, but the webs of the girders are $\frac{5}{8}$ in. thick.

Engineers are approaching a belief in simplicity of design, and that the fewer the actual number of members used, the better. If the metal in the web can be made to take the stresses directly, and without the aid of stiffeners, it is a great deal better, very largely because it is absolutely impossible to determine with the remotest degree of certainty how such stiffeners will act.

F. D. Rhodes, Jun. Am. Soc. C. E.—The speaker's experience in Mr. Rhodes.
designing girders for buildings points conclusively to the advantage of using the graphical method for spacing rivets when the girders are subject to combinations of concentrated and distributed loads, or any kind of loading which gives an unsymmetrical moment diagram.

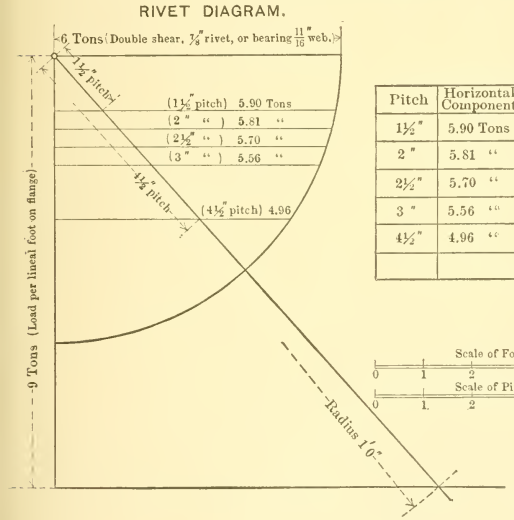

RIVET DIAGRAM.
6 Tons (Double shear, ⅞" rivet, or bearing 11/16" web.)
1½" pitch
(1½" pitch) 5.90 Tons
(2 " ") 5.81 "
(2½" ") 5.70 "
(3 " ") 5.56 "
4½" pitch
(4½" pitch) 4.96
9 Tons (Load per lineal foot on flange)
Radius 10'
Scale of Forces, in Tons
0 1 2 3 4 5 6
Scale of Pitch, in Inches
0 1 2 3 4 5 6

TABLE.

Pitch	Horizontal Component	Shear	Calculation
1½"	5.90 Tons	114 Tons	$\frac{5.90 \times 29}{1.5}$
2 "	5.81 "	84.2 "	$\frac{5.81 \times 29}{2}$
2½"	5.70 "	66.1 "	$\frac{5.70 \times 29}{2.5}$
3 "	5.56 "	53.7 "	$\frac{5.56 \times 29}{3}$
4½"	4.96 "	32.0 "	$\frac{4.96 \times 29}{4.5}$

$$S = \frac{r' \times h}{p}$$

$h = 36" - 7" = 29"$

Fig. 10.

It has been contended that the author's method involves extra labor, as it necessitates the plotting of a shear diagram; but in cases of the kind just mentioned it is the speaker's belief that graphic statics will most quickly and accurately determine the length and position of the cover-plates, and that it requires but very little extra labor to plot the shear diagram directly off the load line of the force polygon.

Mr. Rhodes. Girders in buildings often carry walls or floor arches which are supported directly by the flanges, for which cases the speaker's practice, in determining the shear values for the various pitches, differs from the author's, as is shown in Fig. 10, and the accompanying table. The example is taken from the design of a 36-in. girder, web $\frac{11}{16}$ in. thick, rivets $\frac{7}{8}$ in., with the top flange carrying a load of 9 tons per lineal foot.

The horizontal components are scaled directly off the rivet diagram, the calculations are made with a slide rule, and the shears are then plotted on the shear diagram.

Mr. Jonson. Ernst F. Jonson, Assoc. M. Am. Soc. C. E. (by letter).—The author's method of spacing rivets in plate girders is undoubtedly the most convenient one yet proposed. There are, however, some points in the paper which require further consideration. In order that the problem of the plate girder may be better understood, it is necessary to find the actual stresses in the web.

These stresses may be found by the following graphical method:

Let s = total vertical shear;

m = unit shear at neutral axis;

t = increase of extreme fiber stress per unit of length of girder;

a = area of girder section;

w = thickness of web;

r = radius of gyration of girder section;

d = distance from neutral axis to extreme fiber;

b = distance from neutral axis to center of gravity of half girder section.

We know that $s = \frac{a\, r^2\, t}{d}$, or $t = \frac{s\, d}{a\, r^2}$.

We also know that $w\, m = \frac{a}{2}\, \frac{t\, b}{d}$.

Hence, $m = \frac{b\, s}{2\, r^2\, w}$ ..... *I*

and $s = \frac{2\, m\, r^2\, w}{b}$ ..... *II*

Draw a sectional view of the girder, Fig. 11, and construct a Mohr diagram of the square of the radius of gyration. This is done in the following way: Divide the cross-section of the girder into a number of parts (twelve in the figure). Take half the cross-section area as pole distance *C D*. Lay off the parts of one-half of the cross-section area on the line *C E*. Draw the moment diagram *B C G* as if the parts of the cross-section area were forces acting in the center of gravity of each part. The horizontal ordinates of the curve *C G* multiplied by the pole distance *C D* give then the moment of the part of the cross-section area outside the point in which the ordinate is

taken. Hence, $B\ G$ is the distance from the neutral axis to the center of gravity of the half cross-section; $B\ G = b$. Mr. Jonson.

Since the horizontal bases of the triangles of which the area $B\ C\ G$ is composed represent the moments of the various elements of the cross-section divided by half that area, the triangles themselves must represent half the moment of inertia of these elements divided by half the cross-section area. Hence, the area $B\ C\ G$ is equal to half the square of the radius of gyration of the cross-section area with reference to the neutral axis; $B\ C\ G = \frac{r^2}{2}$.

Since the shear at any point in the web is proportional to the cross-section area outside of that point multiplied by the average bending stress acting in that area, *i. e.*, proportional to the moment of the area with reference to the neutral axis, the horizontal ordinates of the curve $A\ G$ are proportional to the shear.

The area $A\ B\ G$ is twice as large as the area $B\ C\ G$, because the trapezoids of which it is made up are twice as large as the corresponding triangles of which the area $B\ C\ G$ is composed; $A\ B\ G = r^2$.

If we now take the pole distance, $A\ F = b$, and draw the moment diagram $A_1\ C_1\ C_2$ with reference to C, we get $C_1\ C_2 \times A\ F = 2 \times A\ B\ G$, or $C_1\ C_2 = \frac{2\ r^2}{b}$. We also get the curve $A_1\ C_2$, the ordinates of which toward the axis $A_2\ C_2$ are proportional to the part of the double area $A\ B\ G$ which lies below the point in which the ordinate is taken. Hence these ordinates are proportional to the compression produced by a load on top of the girder. If we then lay off the load per unit of length divided by the web thickness $A_2\ N$, and draw, by means of parallel lines, the curve $N\ C_2$, with ordinates proportional to those of $A_1\ C_2$, $A_2\ N\ C_2$ is the diagram of the perpendicular compressive unit stress due to the load.

Now, lay off $C_1\ K = 10$, $C_1\ K_1 = 10$, and $C_1\ L = 10w$, and draw the parallel lines $K_1\ L$ and $K\ L_1$, thus making $C_1\ L_1 = \frac{10}{w}$. Lay off $C_1\ M = s$, and draw the parallel lines $C_2\ L_1$ and $M\ M_1$, making $C_1\ M_1 = 10\ m$. For $C_1\ M$ and $C_1\ M_1$, a smaller scale must be used. Lay off $B\ G_1 = m$, and draw, by means of parallel lines, the curve $A\ G_1$ with ordinates proportional to those of curve $A\ G$. These ordinates then represent the unit shear at the various points of the web.

Multiply $C_1\ C_2$ with $\frac{a\ b}{2}$ and lay off the result $A_2\ H = a\ r^2$. Also, lay off the bending moment $A_2\ T$, both to a smaller scale than that of the rest of the diagram. Draw the parallel lines $H\ T$ and $A_3\ C_3$. The triangles $A_2\ A_3\ B_2$ and $B_2\ C_2\ C_3$ are then the diagrams of the unit stresses due to bending; the ordinates of $A_3\ B_2$ representing the compression and those of $B_2\ C_3$ the tension, for the unit stress is to the distance from the neutral axis as the bending moment is to $a\ r^2$.

Mr. Jonson. In order to find the resulting principal stresses* lay off the unit shearing stress on a vertical line from U to R. Take the point Q, dividing the distance $O\,U$ in two equal parts, as a center, and draw the circle $P_1\,R\,P_2$ through R. The two principal stresses are then the tension $P\,P_1$ acting in the direction $P_2\,R$, or $P\,S$, and the compression $P\,P_2$ acting in the direction $P_1\,R$, or $P\,S_1$. Hence, the ordinates of the curve $I_1\,J_1$ represent the tensile stresses, and those of the curve $I_2\,J_2$ the compression stresses.

From the diagram it will be seen that unless the unit shear is very small (in the present case less than one-third of the extreme fiber stress) the maximum stress is not at the extreme fiber, as generally supposed, but in the web at the upper and lower pitch lines.

The shear diagram further shows that the h, in the rivet formula quoted by the author, should be taken as the distance between pitch lines only when the formula is used for rivets in stiffeners supporting concentrated loads or reactions. When used for rivets in flange angles it is quite on the safe side to make h equal to the distance from back to back of angles. In the present case it is even greater than the total height of the girder.

The author holds (page 1047)† that when stiffeners are used, the web takes only a part of the shear, leaving the remainder to the stiffeners. This is clearly impossible, unless the stiffeners are arranged so as to form a complete lattice system. If, in the present case, a stiffener were inserted along the line $A\,C$ it would greatly reduce the vertical compressive stresses $A_2\,C_2\,N$, but would not in any way affect the shearing stresses. It would, however, increase the resistance of the central part of the web by preventing buckling or wrinkling. Unfortunately the theory of wrinkling has not yet been developed, so that the dimensions and spacing of stiffeners and their rivets cannot be calculated. The writer refers to stiffeners proper. Uprights, inserted to transmit a concentrated load or reaction to the web, should be regarded as columns loaded along their whole length and, therefore, subject to a stress proportional to the horizontal ordinates of the curve $A_1\,C_2$. Such uprights may, therefore, as the author says, be calculated for the allowed unit stress. The length, however, should not be more than 120 times the radius of gyration perpendicular to the web, or the length beyond which a column is good for less than one-half of the allowable unit stress of the material, because, in such uprights, the load at the center is one-half of the load at the end.

If the load were applied at the bottom instead of at the top the present diagram would have to be turned upside down. The curve $I_1\,J_1$ would then represent the compressive stress, and the curve $I_2\,J_2$ the tensile stress.

---

* Rankine, "Applied Mechanics," Ch. V., Sec. 3.

† *Proceedings*, Am. Soc. C. E., for November, 1900.

Mr. Jonson.

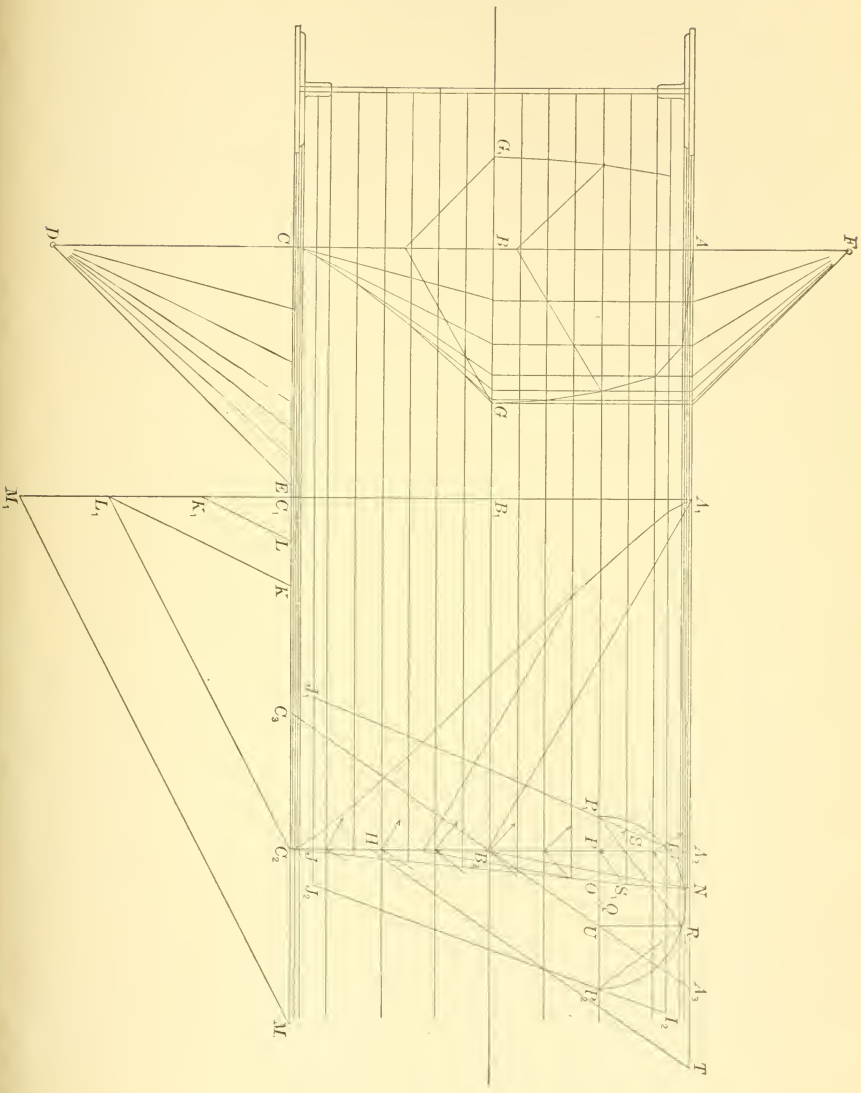


Fig. 11

Mr. Schmitt. E. SCHMITT, Assoc. M. Am. Soc. C. E. (by letter).—Mr. Schaub's statement, deduced from experiment, concerning the erratic behavior of the webs in through and deck-plate girders is of much interest.

In what follows, the writer endeavors to approach the propositions (at least one of them) numerically. An example, arbitrarily chosen, will serve for the investigation, in which the following assumptions have been made:

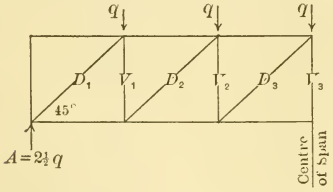
1. The sum of the web stresses in a panel acts along the center lines of imaginary web members of a square-paneled truss, with single diagonals in the panels, the length of each panel being equal to the depth of the truss.*

2. The loads (shear stresses) transmit themselves by the shortest route from the center of the span to the abutments.

3. The same factor of safety is to be maintained at all points in the web. Web members under compressive shear are to be safe against buckling. Compressive and tensile shears are to be considered as compression and tension stresses.

4. The web is to have the same thickness in the two cases.

Beginning with the case of the deck bridge, the imaginary truss will take the form represented in Fig. 12; the position of the diagonals



$D_1 = -A\sqrt{2}$ $V_1 = A - q$

$D_2 = -(A-q)\sqrt{2}$ $V_2 = A - 2q$

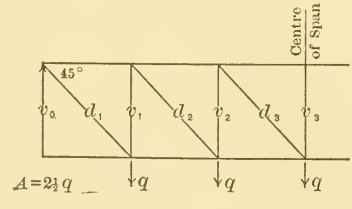
$D_3 = -(A-2q)\sqrt{2}$ $V_3 = A - 2\frac{1}{2}q = 0$

FIG. 12.

enabling the loads to be transmitted "by the shortest route." The stresses obtaining in the web members are noted at the right of the diagram.

The diagonals, only, being in compression, the web will have to be proportioned for the stress obtaining in them.

In the case of the through bridge (or, perhaps, better expressed "trough bridge"), the imaginary truss will be represented by Fig. 13,



$d_1 = +A\sqrt{2}$ $v_1 = -(A-q)$

$d_2 = +(A-q)\sqrt{2}$ $v_2 = -(A-2q)$

$d_3 = +(A-2q)\sqrt{2}$ $v_3 = -(A-2\frac{1}{2}q)$

FIG. 13.

* With the principal stresses acting at 45°, according to the theory of the plate girder, and with the loads concentrated at panel lengths, as assumed, and the further assumption that compressive web stresses will follow the line of least resistance, the arrangement of the direction of the forces, as shown in Fig. 12, suggests itself first. Fig. 13 follows by reversing Fig. 12.

permitting, in a similar manner to that in the first case, the loads to travel by the most direct route from the center of the span toward the abutments. The stresses obtaining in the web members are noted at the right of the diagram. They are of the same magnitude as in the corresponding members of the first case, but opposite in character. The diagonals being in tension and the verticals in compression, the stresses obtaining in the latter will, therefore, govern the dimensioning of the web for buckling. Mr. Schmitt.

Before comparing the compressive stresses per unit of length along the respective web members of the two classes of girders, first determine the ratio of the permissible buckling stress in the diagonals (in compression), of the deck bridge, with the one taking place in the verticals (also in compression), of the through bridge. For this purpose select the empirical formula given by Rankine.

Calling the reduced stress for buckling,

for the diagonals of the deck bridge, P, . . (length of diagonals $= h\sqrt{2}$)

" verticals " through " , p, . . (" " verticals $= h$),

we have, $$P = \frac{k}{1 + c\left(\frac{h\sqrt{2}}{w}\right)^2} \text{ and } p = \frac{k}{1 + c\left(\frac{h}{w}\right)^2},$$

in which, k = simple compression unit;

h = depth of girder;

w = thickness of web;

$$c = \frac{1}{5\,000}.$$

According to the specification, cited by Mr. Schaub, to avoid the use of intermediate stiffeners, assume the web to have a thickness of $w = \frac{1}{50}$ of the depth of the girder.

Introducing the given quantities in the equations for P and p, we obtain, by extending and simplifying, the denominators only of the two fractions,

$$P = \frac{2\,500\ k\ w^2}{2\ h^2}; \quad p = \frac{5\,000\ k\ w^2}{3\ h^2},$$

and dividing the two values, the ratio is found to be:

$$\frac{P}{p} = \frac{2\,500 \times 3\ h^2}{5\,000 \times 2\ h^2} = \frac{3}{4}$$

or, the permissible compressive unit web stress in the deck bridge should be but three-fourths of the stress in the through bridge, due to the difference in length of the members.

Since the web is of the same thickness in the two girders, the foregoing statement would mean that the web in the deck bridge is stressed four-thirds as much as the web of the through bridge, for the same load, and only as far as buckling is concerned.

Mr. Schmitt. Comparing now the ratio of the actual stresses, per unit of length, in the respective representative web members of the two bridges, we will first ascertain, which diagonal (stress) of the deck bridge should be compared with the corresponding vertical (stress) in the through bridge for any of the panels.

Referring to Fig. 12, it is evident that for the panel at the center the compressive stress D_3 will be the governing one, for the whole panel; its influence will extend from the center of the span to the vertical V_3.

In the case of the through bridge, Fig. 13, however, the computation of the web for buckling will begin at the vertical v_2; v_2 being in compression. Reasoning similarly as regards the operation of stresses in the other, related, panels, we can say:

TABLE No. 4.

In the deckbridge, in..... compute web for comp. stress....	1st....2d.....3d panel. D_1...D_2.....D_3	(length of members, $h\sqrt{\ }$)
In the through bridge, at vertical compute web for comp. stress...	1 2 3 v_1.... v_2..... $v_3 = 0$ (or d_3, tension)	(length of members, h.)

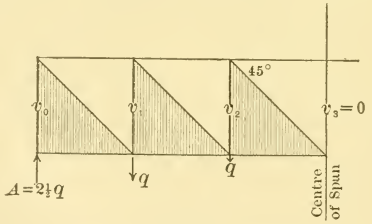


Fig. 14.

The sphere of action of the vertical, compressive stresses in the through bridge is represented in Fig. 14. Any ordinate in any of the triangles represents the columnar lengths of the web, subject, in turn, to the stresses v_0, v_1, v_2.

Vol. XXVII. FEBRUARY, 1901. No. 2.

AMERICAN SOCIETY OF CIVIL ENGINEERS.

INSTITUTED 1852.

PAPERS AND DISCUSSIONS.

NOTE.—This Society is not responsible, as a body, for the facts and opinions advanced in any of its publications.

THE ADJUSTMENT OF A TRANSIT SURVEY AS COMPARED WITH THAT OF A COMPASS SURVEY.

Discussion.*

By GEORGE W. TUTTLE, ESQ.

GEORGE W. TUTTLE, Esq. (by letter).—It is stated on page 1165† of the paper, that the most probable corrections will be those the sum of whose squares is a minimum after each correction has been divided by its probable error. It is the square of the probable error, however, that should be and has been used in the development of the formulas. Mr. Tuttle.

It would be inferred by a reader of the paper that Dr. Bowditch developed his method from least-square considerations, although such is not the case. In *The Analyst*, Vol. 1, No. 4, 1808, Dr. Bowditch presented his well-known method, in answer to a question proposed in a previous number of that journal, as to the best method of correcting a compass survey. Dr. Bowditch did not give the solution in mathematical form, but presented the now common graphical one, stating, in substance, that it was reasonable to assume that the corrections should be proportional to the length of the lines, and parallel to the closing side.

* This discussion (of the paper by Charles L. Crandall, M. Am. Soc. C. E., printed in *Proceedings* for December, 1900) is printed in *Proceedings* in order that the views expressed may be brought before all members of the Society for further discussion.

Communications on this subject received prior to March 30th, 1901, will be printed in a later number of *Proceedings*, and subsequently the whole discussion will be published in *Transactions*.

† December, 1900, *Proceedings*.

Mr. Tuttle. It remained for Dr. Adrian, the editor of *The Analyst*, in the same number, to demonstrate Dr. Bowditch's method by least squares, and this work is remarkable as the earliest application of the method of least squares to geodetic work, as well as for the general and instructive form in which it is given. This problem, and its solution by Dr. Adrian, forms an important and interesting part of the early history of mathematics in the United States. Dr. Adrian demonstrates the following formulas, which are put into the notation of the present paper:

$$\left.\begin{array}{l} x\,(\Sigma\, M\cos.^2 B + p^2\,\Sigma\, M\sin.^2 B) + y\,(1-p^2) \\ \Sigma\, M\sin.\, B\cos.\, B + q_1 = 0 \end{array}\right\} \ldots\ldots\ldots(1)$$

$$\left.\begin{array}{l} y\,(\Sigma\, M\sin.^2 B + p^2\,\Sigma\, M\cos.^2 B) + x\,(1-p^2) \\ \Sigma\, M\sin.\, B\cos.\, B + q_2 = 0 \end{array}\right\} \ldots\ldots\ldots(2)$$

$$\text{or, } x\left[\Sigma\left(\frac{L^2}{l}\right) + p^2\,\Sigma\left(\frac{D^2}{l}\right)\right] + \Sigma\left(\frac{L\,D}{l}\right)(1-p^2)\,y + q_1 = 0 \ldots (3)$$

$$x\,\Sigma\left(\frac{L\,D}{l}\right)(1-p^2) + \left[\Sigma\left(\frac{D^2}{l}\right) + p^2\,\Sigma\left(\frac{L^2}{l}\right)\right] y = 0 \ldots\ldots (4)$$

$$\text{where } p = \frac{\text{Probable error in bearing} \times \text{length of line.}}{\text{Probable error in length of line.}}$$

Equations (3) and (4) are more general forms of the author's Equations (17), which are obtained by making $p = 0$. Dr. Adrian notes, first, that when $p = 1$,

$x = \dfrac{-q_1}{l_1 + l_2 + l_3 + \ldots}$ and $y \dfrac{-q_2}{l_1 + l_2 + l_3 + \ldots}$, then $V_{L1} = x\,l_1$, $V_{D1} = y\,l_1$ and motion of angle points is in the direction of closing line. Second, when $p = 0$, motion of angle points is in the direction of l_1, l_2, l_3..... Third, when $p = \infty$, motion of angle points is in a direction perpendicular to the distances l_1, l_2, l_3,.....

It will be seen that the first case is the method of Dr. Bowditch; the second is that of the author, and supposes all the errors distributed among the sides only, the bearings remaining unchanged. The third solution takes up all the errors of the traverse in the bearings, and the measured distances remain unchanged.

Now, the foregoing general equations can be used with substantially the same amount of work as those proposed by the author, and with the use of his forms of computation. They have the advantage that the errors can be distributed among the sides and angles in any proportion, according to the relative accuracy of the measured sides and angles; these formulas have the defect however, that the correction to the bearing of any line is inversely proportional to the square root of the length of that line, while in a transit survey, where the lines are not excessively short, it should be independent of the distance.

The fundamental defect in the formula proposed by the author is, that it requires the errors to be distributed in the sides only, while the

angular error, where many angles are involved, is often greater. When the errors have to be taken up, either in sides or angles alone, the corrections will, in general, be double what they would be if distributed through both. Mr. Tuttle.

That which follows refers largely to city work, with transits of good make, and reading to 20 seconds, and tapes having spring balance and temperature adjustment.

The probable error in chaining appears to increase less rapidly than the distance, and faster than the square root of the distance as assumed in the foregoing formulas. The law of the square root would probably be true if all errors to which distance measurements were subject were compensating, and made up of a large number of purely accidental errors, an equal number of positive and negative ones occurring. But as most of them are not compensating, and, as for any one line measured in a brief period, temperature and other errors proportional to distance may be considerable and cumulative, it would seem to be quite as accurate to take the error of chaining as being proportional to the distance, in which form the error is usually stated.

It would seem that for an accurate and economical survey, some relation should exist between the accuracy demanded of the chain, and that of the transit. No adjustment that can be devised is so perfect or satisfactory that it can take the place of accurate work. It is quite important, therefore, that the proper relation between the precision of the line and angle measurements should be determined.

Were the angle and distance measurements equally difficult, for the sake of economy, the allowable error should be divided equally between them, as Dr. Bowditch's method assumes. The angular measurements being usually less difficult, some greater precision may be observed in their measurement, but the respective errors, usually, should not depart widely from equality, and in this particular it appears desirable that the assumption implied in the usual rule, *i. e.*, that errors due to chaining and angle measurements are equally probable, should obtain in practice.

Assume a closed traverse of n sides and angles, with an angular error of closure of $a\sqrt{n}$, where a = allowable error in measurement of one angle; then, to make the figure geometrically consistent, as far as the angles are concerned, a correction of $\frac{a\sqrt{n}}{n}$ should be applied to each angle. This is the same, in effect, as assuming the bearing of one line in the traverse, from which the bearings of the other sides are derived, and weighting the two determinations of the bearing of any given side found in passing from the assumed line, round to the right and left, respectively, inversely as the number of angles passed through.

Let m be the value of any bearing determined by passing through

Mr. Tuttle. z angles to the right, and m_1 by passing through $(n - z)$ angles to the left, and m_m and r_m the value and probable error of bearing, after the error of closure is applied.

Then,
$$m_m = \frac{\frac{m}{r^2} + \frac{m_1}{r_1{}^2}}{\frac{1}{r^2} + \frac{1}{r_1{}^2}}$$

where r and r_1 represent the probable error of determination in passing round the closed figure to the right and left, respectively.

It may be observed that the probable error, as here used, is that obtained from the allowable difference of angular closure, *i. e.*, $a\sqrt{n}$, and is consequently the probable error corresponding to this difference, and the maximum value which the probable error should have.

Now,
$$\frac{1}{r^2} = \frac{1}{(0.674a)^2 z}, \text{ and } \frac{1}{r_1{}^2} = \frac{1}{(0.674a)^2 (n - z)},$$

so that
$$m_m = \frac{\frac{m}{z} + \frac{m_1}{n - z}}{\frac{1}{z} + \frac{1}{n - z}} = \frac{m (n - z) + m_1 z}{n} \quad \ldots\ldots\ldots\ldots (5)$$

and
$$r_m = \frac{1}{\sqrt{\frac{1}{r^2} + \frac{1}{r_1{}^2}}} = \frac{0.674a}{\sqrt{\frac{1}{z} + \frac{1}{n - z}}} = 0.674a \sqrt{\frac{n z - z^2}{n}} \quad \ldots\ldots (6)$$

From the foregoing, it is seen that the probable error of the bearing distant $z = \frac{n}{2}$ from the assumed side is $r_{m\left(z = \frac{n}{2}\right)} = 0.34a\sqrt{n}$, while the probable error of a single determination is $r_{\left(z = \frac{n}{2}\right)} = 0.47a\sqrt{n}$. The allowable error, $a\sqrt{n}$, is, therefore, 2.1 times the probable error of a single determination as here defined and used.

It is easily seen from Equation (6) that the probable errors of the corrected bearings vary from zero at the base to $0.34\, a\sqrt{n}$ at the bearing $\frac{n}{2}$ angles distant from the base, in proportion to the ordinate of a circle of diameter n, divided into segments z and $n - z$.

As it is impracticable to assign different probable errors to bearings in the determination of corrections, or to measure the angles so as to secure bearings having a uniform probable error, the square root of the mean value of the squares of the probable errors should be taken as the constant probable error of an angle; this is equivalent to making p^2, in Equations (3) and (4) constant, and equal to its mean value. We will define the square root of the mean of the squares of the probable errors as the mean probable error. The mean prob-

able error of bearing, in a traverse of n angles, will therefore be, approximately, Mr. Tuttle.

$$0.674a\sqrt{\frac{1}{n}}\int_{0}^{n}\left(\frac{nz-z^2}{n}\right)^{\frac{1}{2}}dz = 0.275\,a\sqrt{n},$$

and the mean value of the allowable error, being 2.1 times the latter, will equal $0.58\,a\sqrt{n}$. While this is the mean value of the allowable error in traverse work connected with fixed bearings, it is the actual allowable error in a closed circuit where no bearings are fixed, since each bearing is similarly circumstanced relatively to all the others.

From the record of the angles measured with several good 20-second transits, under service conditions, and by different observers, the probable error of a single angle measurement was found to be less than 12 seconds. This quantity, therefore, is taken as the maximum probable error of a single measurement, and consequently, it is found that $12'' \times 2.1 = 25.0''$ is the allowable error or difference between measurements.

The allowable error of chaining with the tape before described has been found to be about 1 in 10 000, and an angular error of 20.6 seconds will cause an error of an equal amount in the location of the end of any given line. Therefore, when the mean allowable error of a traverse equals 20.6 seconds, the error due to angular measurement will be approximately equal to the error due to chaining, when measured with the accuracy of 1 in 10 000. We have already found the mean allowable error in a traverse of n sides to be $0.58\,a\sqrt{n}$; therefore, to find the value of a for equal precision in angles and chaining, we have the equation $0.58\,a\sqrt{n} = 20.6''$.

Table No. 4 has been prepared from this equation. The first column gives values of n, the number of angles in the traverse. The second, the values of a, the allowable error in angular measurement, *i. e.*, the difference between two measurements should not exceed this amount for equal precision in sides and angles. The third column gives the approximate number of repetitions of angle necessary for equal precision in sides and angles when $p = 10\,000 \times 0.58\,a\sqrt{n}\,\mathrm{arc}\,1'' = 1$.

TABLE No. 4.

n.	a.	Repetitions necessary.
4	18	2
9	12	3
16	9	4
25	7	6
36	6	8

Mr. Tuttle. From a considerable experience in adjusting careful traverse work to triangulation, it has been found that where many angles are involved, the divergence due to angular errors may be considerably greater than errors due to chaining, and in this way the foregoing deductions as to the necessary care in measuring traverses of many angles has been verified.

Equations (1), (2), (3) and (4) may be easily modified to make the probable error in distance measurement proportional to the length of line, and the probable error in bearings independent of the same. The equations then take the form:

$$\left.\begin{array}{c} x\,[\Sigma\ M^2 \cos.^2 B + p^2 \Sigma\ M^2 \sin.^2 B] + y\,(1-p^2) \\ M^2 \sin.\ B \cos.\ B + q_1 = 0 \end{array}\right\} \quad \ldots\ldots(7)$$

$$\left.\begin{array}{c} y\,[\Sigma\ M^2 \sin.\ B + p^2 \Sigma\ M^2 \cos.\ B] + x\,(1-p^2) \\ M^2 \sin.\ B\ \cos.\ B + q_2 = 0 \end{array}\right\} \quad \ldots\ldots(8)$$

or,

$$x\,[\Sigma\ L^2 + p^2 \Sigma\ D^2] + \Sigma\ L\ D\,(1-p^2)\ y + q_1 = 0 \ldots\ldots(9)$$

$$x\,(1-p^2) \Sigma\ L\ D + y\,[\Sigma\ D^2 + p^2 \Sigma\ L^2] + q_2 = 0 \ldots\ldots(10)$$

Now, when the angles and sides are equally well measured, p will equal unity, and we have

$$x = \frac{-q_1}{l_1^2 + l_2^2 + l_3^2 + \ldots.} \qquad V_{L1} = l_1^2\, x \ldots\ldots\ldots\ldots(11)$$

$$y = \frac{-q_2}{l_1^2 + l_2^2 + l_3^2 + \ldots.} \qquad V_{D1} = l_1^2\, y \ldots\ldots\ldots\ldots(12)$$

It will be seen that in these equations the squares of the sides are used in precisely the same way that the sides are used in the common formulas. While the latter make the corrections to be applied to long lines comparatively slight and the corrections to short ones large; Formulas (11) and (12) make the corrections to the location of any given point less when passing along a short side, and greater in the case of a long side, by assuming the probable error in the location of a given point as proportional to the distance to that point, instead of to the square root of the distance.

These equations are so simple, and so readily deduced, that the writer has some misgivings in presenting them as new, although he has no knowledge that they have ever been proposed. They appear to the writer to be superior to the common formulas for the adjustment of transit work, and also have the merit of simplicity.

Rensselaer Polytechnic Institute,
Troy, N.Y.
ESTABLISHED 1824.
A SCHOOL OF ENGINEERING
Local examinations provided for. Send for a Catalogue

LOUISVILLE CEMENT.

The undersigned is General Agent for the following Standard Brands of Louisville Cement:

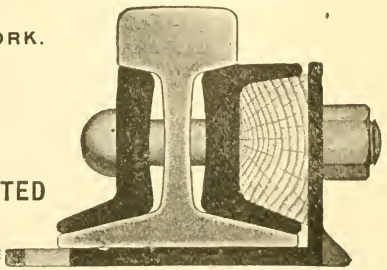
FALLS MILLS (J. Hulme Brand),
BLACK DIAMOND MILLS (River), Diamond Brand,
SPEED MILLS, Star Brand,
FALLS CITY MILLS, Anchor Brand,
BLACK DIAMOND MILLS (Railroad), Diamond Brand.

This Cement has been in general use throughout the West and South since 1830; most of the public works having been constructed with it. Orders for shipment to any part of the country, by rail or water, will receive prompt and careful attention.

Sales for 1892: 2,145,568 Barrels.

WESTERN CEMENT COMPANY,
247 W. Main St., Louisville, Ky.

THE WEBER RAILWAY JOINT MFG. CO.
EMPIRE BUILDING,
71 BROADWAY, NEW YORK.
BRANCHES:
BOSTON, MASON BLDG.
CHICAGO, OLD COLONY BLDG.
BALTIMORE, EQUITABLE BLDG.
—o—
Manufacturers of
"T" STEP and INSULATED
JOINTS.



ESTABLISHED 1845.

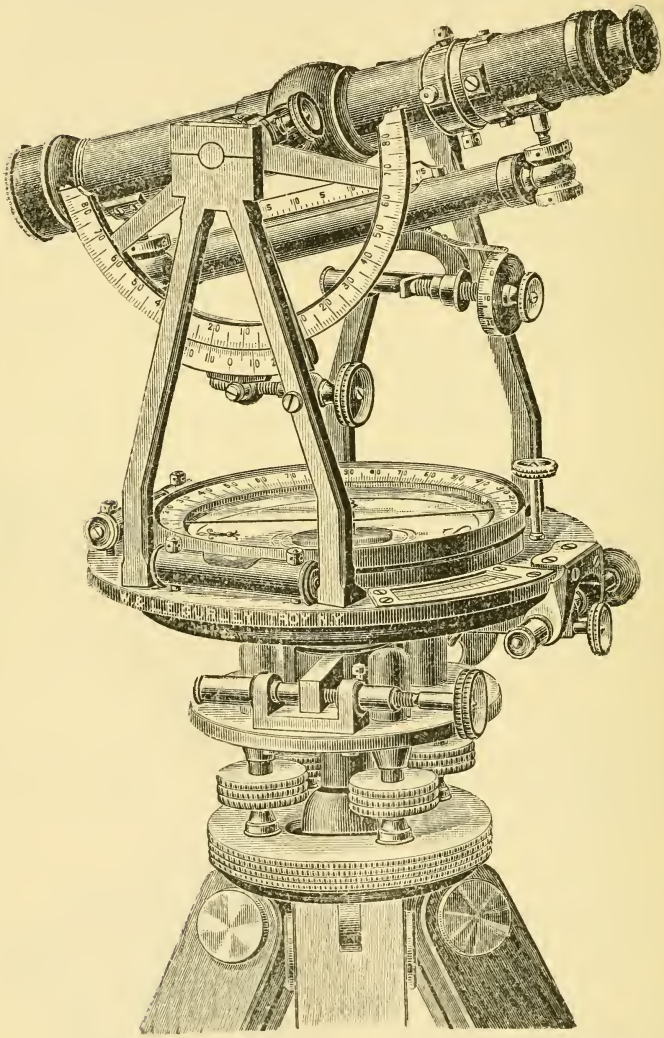
W. & L. E. GURLEY

TROY, N. Y., U. S. A.

LARGEST MANUFACTURERS IN AMERICA OF

Civil Engineers' and Surveyors' Field Instruments.

TRANSITS, LEVELS, COMPASSES, PLANE TABLES, CURRENT METERS.

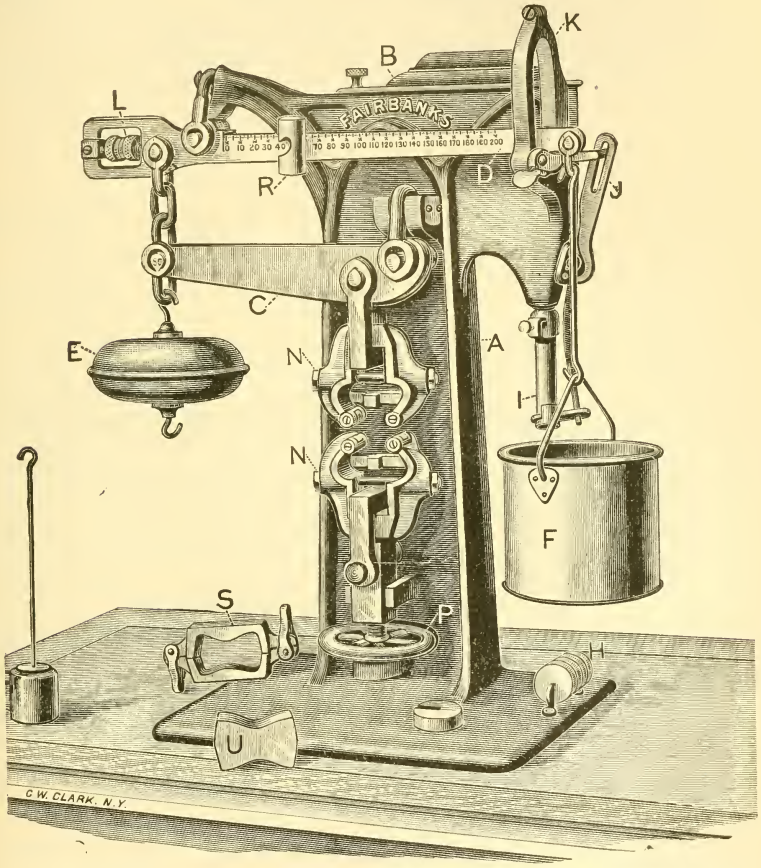


LEVELING RODS, CHAINS, TAPE LINES, ANEMOMETERS, BAROMETERS, ODOMETERS.

LATEST CATALOGUE MAILED ON APPLICATION.

FAIRBANKS'

PATENT AUTOMATIC CEMENT TESTING MACHINES.



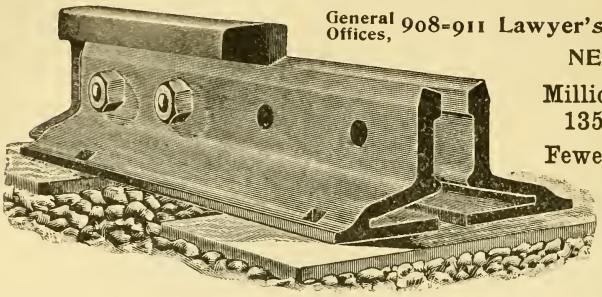
Descriptive Circular of Machines and Appliances, with Prices, Forwarded on Application.

The Fairbanks Company,

311 BROADWAY, NEW YORK.

ALBANY, N. Y.; BALTIMORE, Md.; BUFFALO, N. Y.;
BOSTON, Mass.; PHILADELPHIA, Pa.; PITTSBURG, Pa.; NEW ORLEANS, La.;
MONTREAL, Que.; LONDON, England.

CONTINUOUS RAIL JOINT CO. of AM.



General Offices, 908-911 Lawyer's Building,
NEWARK, N. J.

Millions in use on 135 Railroads.

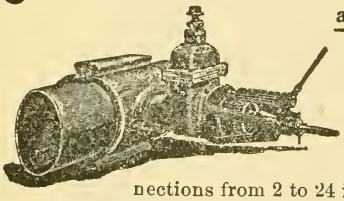
Fewest parts possible. Provides for the increased tonnage up to date.

BEST ECONOMICAL RESULTS.

GIANT PORTLAND,
EGYPT PORTLAND,
IMPROVED UNION,
AND UNION CEMENTS.

MANUFACTURED BY
AMERICAN CEMENT CO., Egypt, Pa.,
LESLEY & TRINKLE, Sales Agents,
22 & 24 South 15th St., Philadelphia.

Connecting Branch Sleeve and Tapping Apparatus



For making Large Connections without Shutting Off Water or Reducing Pressure.

This is no experiment, but has been used by the Water Departments of numerous cities for years with entire success. Connections from 2 to 24 ins. have been made with mains from 4 to 48 ins. For full information, address

THE A. P. SMITH MFG. CO., 921 Prudential Building, Newark, N. J.

The Evening Post Job Printing House,

FULTON STREET, CORNER BROADWAY,

NEW YORK.

PRINTERS OF PERIODICALS.

ALCATRAZ ASPHALT

Guaranteed free from Coal Tar or Petroleum Residuum,

For Reservoir Linings and Pipe Coatings.

The Alcatraz Co.

General Offices: Bryson Block, Los Angeles, Cal., and Crocker Building, San Francisco, Cal.

ATLANTIC, GULF AND PACIFIC CO.

Hydraulic Dredge discharging through 5,700 ft. of pipe.

ENGINEERS AND CONTRACTORS

Geo. W. CATT, M Am. Soc. C. E., M. Inst. C. E., Pres. & Eng. THOS. J. LONG, M. Am. Soc. C. E., Vice Pres. & Engr.
H. S. WOOD, C. E., Sec. & Treas. H. KRUSI, C.E., Pac. Coast Man. R. A. PERRY, Supt

SPECIALTIES: Dredging, Dredging Machines, Land Reclamation, Docks, Piers, Foundations, Bridges.
Correspondence solicited.

MAIN OFFICE: PARK ROW BUILDING, NEW YORK.
PACIFIC COAST OFFICE: 220 MARKET STREET, SAN FRANCISCO, CAL.

WEST PASCAGOULA CREOSOTE WORKS,

WEST PASCAGOULA, MISS.

Situated on Pascagoula Bay and on the line of the Louisville and Nashville Railroad.

These works have been in operation for more than twenty years, were recently entirely rebuilt and enlarged, and are now prepared to execute all orders for creosoted piles and timber thoroughly impregnated with dead oil of coal tar.

New cylinders 115 feet long. Capacity, one million feet per month.

Address S. W. LABROT,
SUPT. WEST PASCAGOULA CREOSOTE WORKS,
West Pascagoula, Miss.

15,000,000 BARRELS

"HOFFMAN" CEMENT

Have been used on important works throughout the United States.

NO OTHER CEMENT COMPANY CAN SHOW SUCH A RECORD.

"DRAGON" PORTLAND

Specified by Architects and Engineers since 1889 on National, Munic'pal and Railroad Improvements.

Sales Office, No. 1 Broadway, New York.
Philadelphia Office, Harrison Building, 15th and Market Sts.

THE LAWRENCE CEMENT COMPANY.

E. R. ACKERMAN, PRES.

ASSOC. AM. SOC. C. E.

ESTABLISHED 1856.

Warren Foundry and Machine Co.

WORKS AT PHILLIPSBURG, NEW JERSEY.

SALES OFFICE: 160 BROADWAY, NEW YORK.

CAST-IRON, WATER AND GAS PIPE,

FROM 3 TO 48 INCHES DIAMETER.

Also all sizes of FLANGED PIPE and SPECIAL CASTINGS.

THE F. O. NORTON COMPANY,

—MANUFACTURER OF—

Hydraulic Cement,

92 BROADWAY, NEW YORK.

Particularly adapted for work under water, for which use it is superior to the best Portland Cement, when used 1 to 1.

Certificates of tests and reports on actual use in important public works furnished on application.

OUR LEADING

Architects, Engineers and Builders

SPECIFY AND USE

BROOKLYN BRIDGE BRAND

ROSENDALE HYDRAULIC CEMENT.

USED EXCLUSIVELY ON { PARK ROW OFFICE BUILDING—30 STORIES. WALDORF-ASTORIA HOTEL—LARGEST IN THE WORLD.

HAVE SUPPLIED FOR NEW YORK CROTON AQUEDUCT, IN 1897 AND 1898, 165,000 BARRELS.

ATLAS Portland Cement

IS THE STANDARD AMERICAN PORTLAND.

The U. S. Government gives it preference over all other brands.

ATLAS PORTLAND CEMENT CO.,

143 LIBERTY STREET, NEW YORK CITY.

IRONCLAD PORTLAND CEMENT

Manufactured by GLENS FALLS PORTLAND CEMENT CO.

Sole Selling Agent, Commercial Wood & Cement Co.,

156 FIFTH AVENUE, NEW YORK.

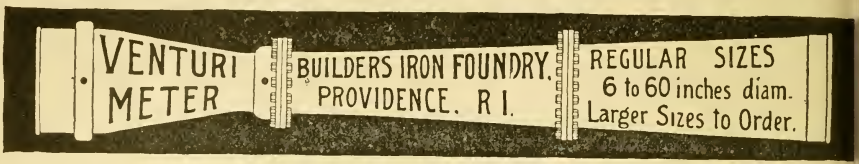
High-grade American PORTLAND CEMENT unsurpassed for making Fine Artificial Stone.

LABORATORIES OF Dr. CHAS. F. McKENNA, 221 PEARL ST., NEW YORK.

Successor to Dr. GIDEON E. MOORE.

DEPARTMENT OF CHEMISTRY. Analyses and Assays of Ores, Metals, Waters and Natural and Industrial Products of every description.

DEPARTMENT OF PHYSICAL TESTS. Tensile, Transverse and Compression Tests of Iron, Steel and other Metals and Alloys, Cements, Building Stones and Engineering Materials generally.



THE VENTURI METER is the only practical meter for measuring large quantities of water.

ITS ACCURACY is unquestioned and it is frequently employed to test the accuracy of pumps.

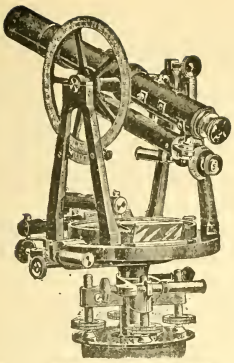
NO BY-PASS is necessary, and the cost of tees, elbows and gate-valve is avoided.

Otis Elevator Company.

HYDRAULIC,
ELECTRIC AND
STEAM ELEVATORS

For Passengers and Freight.

NEW YORK, BOSTON,
CHICAGO, PITTSBURG,
PHILADELPHIA, SAN FRANCISCO.



ESTABLISHED 1872.

F. E. BRANDIS SONS & CO.,

MANUFACTURERS OF

Engineers' and Surveyors' Instruments,

814 GATES AVENUE,

BROOKLYN, NEW YORK.

Catalogues mailed on application.

THE RAND DRILL COMPANY,

Pioneers in Rock Drilling and Air Compressing Machinery,

128 BROADWAY, NEW YORK,

HAS BEEN AWARDED

THREE GOLD MEDALS

AT THE

PARIS EXPOSITION

For AIR COMPRESSORS and ROCK DRILLS.

Eppinger & Russell Co.,

CREOSOTING WORKS,

Dead Oil of Coal Tar Process.

Piles and Timber treated with the above Oil for all purposes, when preservation is desired.

Introduced in England by Mr. Bethel in 1838. **DEAD OIL OF COAL TAR** is the only known product of commercial application that will preserve **TIMBER FROM DECAY, LAND AND MARINE INSECTS.**

Our Mr. Valentine has had practical experience since 1872, and we have specimens of Piles and Timber treated by him in 1874, which are in use to-day and are in a perfect state of preservation. **We have the largest and best equipped plant in the world. Cylinders 100 ft. long, capacity 1,500,000 ft. per month.**

Direct Water and Rail Communications.

MANUFACTURERS OF THE

Valentine Electrical Subway Conduit.

WORKS:
Foot First Street and Newtown Creek,
LONG ISLAND CITY.

OFFICES:
MORRIS BUILDING
66 BROAD ST., NEW YORK.

SEND FOR CIRCULARS AND PRICES.

The Brown Hoisting Machinery Co.,

INCORPORATED,

Engineers, Designers and Manufacturers of Special Machinery for the Economical Handling of COAL AND ORE.

BRIDGE TRAMWAY UNLOADERS for Discharging Bulk Cargoes from Vessels to Cars or Storage on Dock.

FAST PLANT UNLOADERS, for Handling Bulk or Package Freight.

CRANES of Every Type.

Main Office and Works, CLEVELAND, OHIO, U. S. A.

NEW YORK. PITTSBURG. LONDON.

EXTENT OF ASPHALT PAVEMENTS

IN THE UNITED STATES AND CANADA.

Trinidad Lake Asphalt Pavement, 21,527,415 square yards, or 90%

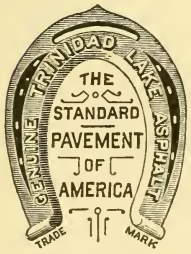
Other kinds Asphalt Pavement, 2,307,064 square yards, or 10%

OF THE TRINIDAD LAKE ASPHALT PAVEMENT

10,000,000 square yards, or nearly 50%,

WAS LAID BY

THE BARBER ASPHALT PAVING COMPANY.



This is equal to about 650 miles of Roadway, 26 feet wide.

The Asphalt used by this Company is from the famous Pitch Lake in the Island of Trinidad, B. W. I.

Plans and Estimates Furnished on Application.

GENERAL OFFICES:

LE DROIT BUILDING, · · · WASHINGTON, D. C.

BOWLING GREEN BUILDING, No. 11 Broadway, New York.

F. V. GREENE, President.

SUPERIOR GRAPHITE PAINT

For BRIDGES, ROOFS, . STRUCTURAL IRON, ...

And all Exposed Metal or Wood Surfaces.

Warranted not affected by heat, cold, salt brine, acid fumes, smoke or chemicals. . . . . .

Detroit Graphite Mfg. Co.,

DETROIT, MICH.

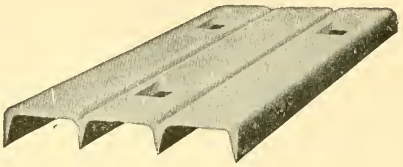
THE

Q & W Tie Plate

ALTHOUGH SOMETHING NEW,

Has a Record, from the fact that it is a combination of the

SERVIS AND WOLHAUPTER PLATES.....



THE Q AND C

CHICAGO:
700-712 Western Union Building.
NEW YORK:
106 Liberty Street.
SAN FRANCISCO:
537 Mission Street.

PROCEEDINGS

OF THE

AMERICAN SOCIETY OF CIVIL ENGINEERS.

SELECT ADVERTISEMENTS WILL BE RECEIVED AT THE FOLLOWING RATES:

	ONE YEAR. 10 INSERTIONS.	½ YEAR. 5 INSERTIONS.	3 INSERTIONS.
One Page.....	$170 00	$95 00	$60 00
One-half Page.....	90 00	55 00	35 00
One-quarter Page	50 00	30 00	20 00
One-twelfth Page, Card	20 00	.....	.....

Address the Secretary of the Society, 220 West 57th Street, New York.

THE

AMERICAN BRIDGE COMPANY

DESIGNERS AND
BUILDERS OF . .

Steel Bridges, Steel Buildings

AND ALL CLASSES OF

Metallic Structures.

OFFICES:

100 BROADWAY, NEW YORK.

AMERICAN SOCIETY

OF

CIVIL ENGINEERS

PUBLIC LIBRARY
BROOKLINE

March, 1901

PROCEEDINGS = VOL. XXVII—No. 3

AMERICAN SOCIETY OF CIVIL ENGINEERS FOUNDED 1852

Published at the House of the Society, 220 West Fifty-seventh Street, New York, the Fourth Wednesday of each Month, except June and July.

Copyrighted, 1901, by the American Society of Civil Engineers.
Entered as Second-Class Matter at the New York City Post Office, December 15th, 1896.

Vol. XXVII. MARCH, 1901. No. 3.

PROCEEDINGS

OF THE

AMERICAN SOCIETY OF CIVIL ENGINEERS.

Edited by the Secretary, under the direction of the Committee on Publications.

CONTENTS.

SOCIETY AFFAIRS.

PAGE.

Minutes of Meetings:
Of the Society, March 6th and 20th, 1901 81
Of the Board of Direction, March 5th, 1901 84
Announcements:
Hours during which the Society House is open 85
Meetings 85
Annual Convention 85
Committee on the Proper Manipulation of Tests of Cement 86
Recent Engineering Articles of Interest 87
New Books of the Month 93
Donations to the Library 94
Membership 95

PAPERS AND DISCUSSIONS.

Discussions on Papers which have been presented:

The Theory and Practice of Precise Spirit Leveling.
By David A. Molitor, M. Am. Soc. C. E. 126

The Adjustment of a Transit Survey as Compared with that of a Compass Survey.
By Messrs. J. H. Fuertes, W. H. Luster, Jr., and W. B. Lee 150

The Construction of Gravity Sand Filters at Nyack, N. Y.
By Messrs. James S. Haring. J. H. Fuertes, G. Kaufman and Morris Knowles 156

Discussion on Topics presented at the Convention:

Filtration of Water for Public Use.
By Messrs. Gustav Heinke and Nicholas Simin 164

MEMOIRS OF DECEASED MEMBERS.

Edward Arnold Correa, M. Am. Soc. C. E. 169
William Giddings Curtis, M. Am. Soc. C. E. 172
Randell Hunt, M. Am. Soc. C. E. 175
Niles Meriwether, M. Am. Soc. C. E. 178
Marc John Reiseger, M. Am. Soc. C. E. 180
William Howard White, M. Am. Soc. C. E. 181
Joseph Ruggles Richards, Assoc. Am. Soc. C. E. 183
John Montgomery Toucey, F. Am. Soc. C. E. 187

The prices of publications are as follows: *Proceedings*, $6 per annum; *Transactions*, $10 per annum. Postage will be added when *Proceedings* are sent to foreign countries.

American Society of Civil Engineers.

OFFICERS FOR 1901.

President, J. JAMES R. CROES.

Vice-Presidents.

Term expires January, 1902:	*Term expires January, 1903:*
RUDOLPH HERING,	HENRY S. HAINES,
ALFRED NOBLE,	GEORGE H. BENZENBERG.

Secretary, CHARLES WARREN HUNT.

Treasurer, JOSEPH M. KNAP.

Directors.

Term expires January, 1902:	*Term expires January, 1903:*	*Term expires January, 1904:*
JOHN A. BENSEL,	JOHN F. O'ROURKE,	JOSIAH A. BRIGGS,
C. W. BUCHHOLZ,	HENRY B. SEAMAN,	GEORGE F. SWAIN.
SAMUEL WHINERY,	THOMAS H. JOHNSON,	EMIL KUICHLING,
EDMUND K. TURNER,	JOSEPH RAMSEY, JR.,	MORDECAI T. ENDICOTT
PALMER C. RICKETTS,	HENRY B. RICHARDSON,	EDWARD C. CARTER,
JAMES D. SCHUYLER.	GEORGE A. QUINLAN.	FRANK C. OSBORN.

Assistant Secretary, T. J. McMINN.

Standing Committees.

THE PRESIDENT OF THE SOCIETY IS *ex-officio* MEMBER OF ALL COMMITTEES.

On Finance:	*On Publications:*	*On Library:*
SAMUEL WHINERY,	RUDOLPH HERING,	JOHN A. BENSEL,
C. W. BUCHHOLZ,	PALMER C. RICKETTS,	H. S. HAINES,
JOSIAH A. BRIGGS,	JOHN F. O'ROURKE,	M. T. ENDICOTT,
G. H. BENZENBERG,	JAMES D. SCHUYLER,	E. KUICHLING,
GEORGE F. SWAIN.	ALFRED NOBLE.	CHARLES WARREN HUNT.

Special Committees.

ON ANALYSIS OF IRON AND STEEL:—Sub-Committee of the American Society of Civil Engineers (of the International Committee on Standards for the Analysis of Iron and Steel, of which Prof. J. W. Langley is Chairman)—Charles B. Dudley, William Metcalf, Thomas Rodd.

ON UNITS OF MEASUREMENT:—George M. Bond, William M. Black, R. E. McMath Charles B. Dudley, Alexander C. Humphreys.

ON THE PROPER MANIPULATION OF TESTS OF CEMENT:—George F. Swain, Alfred Noble, George S. Webster, W. B. W. Howe, Louis C. Sabin, S. B. Newberry, Clifford Richardson, R. L. Humphrey, F. H. Lewis.

The House of the Society is open every day, except Sunday, from 9 A.M. to 10 P.M.

HOUSE OF THE SOCIETY—220 WEST FIFTY-SEVENTH STREET, NEW YORK.

TELEPHONE NUMBER. - - - 533 Columbus.
CABLE ADDRESS. - - - - "Ceas, New York."

Vol. XXVII. MARCH, 1901. No. 3.

AMERICAN SOCIETY OF CIVIL ENGINEERS.

INSTITUTED 1852.

PROCEEDINGS.

NOTE.—This Society is not responsible, as a body, for the facts and opinions advanced in any of its publications.

SOCIETY AFFAIRS.

CONTENTS:

	PAGE
Minutes of Meetings:	
Of the Society, March 6th and 20th, 1901	81
Of the Board of Direction, March 5th, 1901	84
Announcements:	
Hours during which the Society House is open	85
Meetings	85
Annual Convention	85
Committee on Proper Manipulation of Tests of Cement	86
Recent Engineering Articles of Interest	87
New Books of the Month	93
Donations to the Library	94
Membership	95

MINUTES OF MEETINGS.

OF THE SOCIETY.

March 6th, 1901.—The meeting was called to order at 8.45 P. M., President J. James R. Croes in the chair; Charles Warren Hunt, Secretary; and present, also, 74 members and 4 visitors.

The minutes of the meetings of February 6th and 20th were approved as printed in *Proceedings* for February, 1901.

The Chair appointed Messrs. Theodore Paschke and F. A. Burdett as tellers to canvass the ballot on the proposed amendment to Section 5 of Article II of the Constitution.

A paper by Theodore Horton, Assoc. M. Am. Soc. C. E., entitled "Flow in the Sewers of the North Metropolitan Sewerage System of Massachusetts," was presented by the author.

The paper was discussed by Messrs. Rudolph Hering, J. H. Fuertes, J. Waldo Smith, G. W. Tillson, G. C. Whipple and the author.

The tellers appointed to canvass the ballot on the proposed amendment to the Constitution* made the following report:

Total number of ballots received		460
Without signature	8	
Blank	4	
	—	12
Counted		448
Yes	282	
No	166	
	—	448

Number necessary to carry....299.

THEODORE PASCHKE,
F. A. BURDETT.

The President declared the amendment lost.

Ballots were canvassed, and the following candidates were declared elected:

AS MEMBERS.

JAMES RUSSELL CHAPMAN, Chicago, Ill.
JOHN NEEDELS CHESTER, Pittsburg, Pa.
WILLIAM PIERSON FIELD, Newark, N. J.
FRANK EUGENE HULL, Greenville Junction, Me.
JAMES BUTTON CLYDE LOCKWOOD, Seattle, Wash.
BENJAMIN FRANKLIN MACKALL, Portsmouth, Va.
MELVILLE EMERSON REED, Cascade Tunnel, Wash.
LEONARD CHARLES LINDSAY SMITH, Astoria, Long Island City, N. Y.
MASON ROMEYN STRONG, New York City.
HORATIO HARTLEY TRUNDLE, Washington, D. C.
CLAUDE ALLEN PORTER TURNER, Minneapolis, Minn.
JOHN SHAW WALKER, Perth, Western Australia.
DANIEL MERRICK WHEELER, Worcester, Mass.
LUTHER REESE ZOLLINGER, Philadelphia, Pa.

AS ASSOCIATE MEMBERS.

ALEXANDER GEORGE ALLEN, Topeka, Kans.
ADRIAN BENONI BENTZON, Lima, Peru.
CHARLES PIERRE BONNETT, Elizabeth, N. J.
THOMAS JENKS CARLILE, Philadelphia, Pa.
ARTHUR JAMES DYER, Nashville, Tenn.

* The proposed amendment to the Constitution is printed in full in the present volume of *Proceedings*, Vol. xxvii, p. 38.

Howard Nicholas Eavenson, Uniontown, Pa.
Herman Karl Endemann, Brooklyn, N. Y.
Philip Patrick Farley, Brooklyn, N. Y.
Charles Emerson Gregory, New York City.
Foster Haven Hilliard, Memphis, Tenn.
Charles Calvin Huestis, New York City.
Charles Lincoln Keller, Chicago, Ill.
Edgar Walter McCormack, Mayari, Santiago, Cuba.
Frank Pape McKibben, Boston, Mass.
John Newton Shannahan, Gloversville, N. Y.
Oscar Emil Strehlow, Powers, Ala.
Watson Vredenburgh, Jr., New York City.

The Secretary announced the election by the Board of Direction, on March 5th, 1901, of *Sir* Douglas Fox, Cor. M. Am. Soc. C. E., as Honorary Member.

The Secretary announced the election of the following candidates by the Board of Direction, on March 5th, 1901:

As Associates.

Edgar Tweedy Belden, New York City.
Edwin Clarence Eckel, Albany, N. Y.
James Augustus Kelley, Philadelphia, Pa.

As Juniors.

Allan Wadsworth Carpenter, New York City.
James Dougan, New York City.
Carl Hamilton Fuller, Steelton, Pa.
Harry Van Vleck Gifford, Toledo, Ohio.
Leslie McHarg, Detroit, Mich.
Leon Merz, Harrisburg, Pa.
John Ogden Van Brakle, New York City.
Clinton Glencairn Wells, Baltimore, Md.
Henry Amerman Young, Havana, Cuba.

The Secretary announced the following deaths: John Hislop; elected Member May 1st, 1895; died February 22d, 1901. George McCracken Rusling; elected Member November 1st, 1882; died February 26th, 1901. Stephen Paschall Morris Tasker; elected Fellow September 20th, 1872; date of death unknown.

Adjourned.

March 20th, 1901.—The meeting was called to order at 8.40 P.M.; President J. James R. Croes in the chair; Charles Warren Hunt, Secretary; and present, also, 62 members and 11 guests.

A paper, entitled "Heavy Railway Construction in Wyoming," by J. I. Boggs, Assoc. M. Am. Soc. C. E., was presented in abstract by Edward P. North, M. Am. Soc. C. E.

A written discussion by Emile Low, M. Am. Soc. C. E., was presented by the Secretary.

The subject was discussed further by the President, and Messrs. H. J. Howe, Edward P. North and H. G. Prout.

Adjourned.

OF THE BOARD OF DIRECTION.

(Abstract.)

March 5th, 1901.—8.05 P. M.—President Croes in the chair; Charles Warren Hunt, Secretary, and present, also, Messrs. Bensel, Briggs, Buchholz, Carter, Knap, O'Rourke, Osborn, Ricketts, Seaman, Swain, Turner and Whinery.

Ballots were canvassed on the proposal of the name of *Sir* Douglas Fox for Honorary Member, and, by unanimous vote of the Board of Direction and all living Past-Presidents, he was elected.

Applications were considered and other routine business transacted.

Three candidates for Associate and nine for Junior were elected.

Adjourned.

ANNOUNCEMENTS.

The House of the Society is open from 9 A. M. to 10 P. M. every day, except Sundays, Fourth of July, Thanksgiving Day and Christmas Day.

MEETINGS.

Wednesday, April 3d, 1901.—8.30 P. M.—A regular business meeting will be held, at which ballots for membership will be canvassed.

In the absence of any formal paper printed in advance, the meeting will be devoted to an Informal Discussion on the Subject of "The Shrinkage or Compressibility of Earth in Embankments." Samuel Whinery, M. Am. Soc. C. E., will introduce the subject, and a communication from Alexander E. Kastl, M. Am. Soc. C. E., describing the shrinkage of soil stripped from a reservoir site and compacted in 6-in. layers, will be presented. It is hoped that members who have data on this subject, will open their note books, and give the benefit of their experience to the profession, either by relating it at the meeting, or sending notes to the Secretary for presentation.

ANNUAL CONVENTION OF 1901.

The Thirty-third Annual Convention of the Society will be held at Niagara Falls, N. Y., on Tuesday, Wednesday, Thursday and Friday, June 25th, 26th, 27th and 28th, 1901.

The rule adopted by the Board of Direction, February 28th, 1899, provides that no formal papers shall be set down for presentation to the Annual Convention, but in lieu thereof discussion be asked for on all papers which have been published in *Proceedings* during the six months immediately preceding.

It also provides that special subjects of engineering interest which may have been suggested to and approved by the Committee on Publications shall also be presented for discussion.

The success and professional value of this method may be seen by reference to the publications, and the following list of subjects chosen for discussion at the last two conventions is given for the information of members.

List of Subjects Presented for Discussion at the Annual Conventions of 1899 and 1900.

"Should the use of the method of Wheel-Concentrations be discontinued in determining the Stresses in Railroad Bridges?

"In view of present knowledge of the Effect of Repeated Applications of Load, should Fatigue Formulas be used in Bridge Design?

"(*a*) Should Stream Contamination by the Sewage of Cities be absolutely prohibited by law?

"(*b*) Should the Purification of the Sewage of Cities be compulsory, and is this feasible for Large Cities?

"(*c*) Is Filtration the coming solution of the Pure-Water Question for Cities?

"What is the Proper Friction Coefficient for use in the design of Riveted Steel Pipe?

"What are the economic conditions under which Electricity may be profitably substituted for Steam in the operation of Branch Railroad Lines, and what are the engineering requirements to be considered in such substitution?

"What is the present development of the so-called Telferage System for moving either Freight or Passengers? What are the conditions under which that System is preferable to movement by Rail, and what is its adaptability to still further application in competition with Rail Lines?

"Height of Buildings.

(1) What considerations should limit the height of buildings?

(2) Do recent developments in construction, sanitation, intercommunication and economy of administration, warrant the removal of all restrictions?

"Recent Practice in Rails.

The progressive increase in weight; the increase in hardness, particularly in carbon; the sections in most general use; the effect of changes in weight, composition and section.

"Filtration of Water for Public Use.

The several processes now used for the removal of objectionable matter; their comparative sanitary effect, cost and reliability."

The only way of ascertaining what special subjects will be of interest as topics for discussion at the Convention of 1901 is by appealing to the membership for suggestions. Such suggestions, forwarded to the Secretary, will be presented to the Publication Committee.

The foregoing notice was printed in last month's issue, but it is regretted that, up to the present time, no suggestion of any kind has been received. The notice is reprinted now in the hope that some subjects, at least, may be brought by members to the attention of the Committee.

COMMITTEE ON THE PROPER MANIPULATION OF TESTS OF CEMENT.

The following members have been added to the Committee on the Proper Manipulation of Tests of Cements: Messrs. S. B. Newberry, R. L. Humphrey, Clifford Richardson and F. H. Lewis.

Mr. H. W. York has resigned from that Committee.

MONTHLY LIST OF RECENT ENGINEERING ARTICLES OF INTEREST.

(February 14th to March 13th, 1901.)

NOTE.—*This list is published for the purpose of placing before the members of the Society the titles of current engineering articles, which can be referred to in any available engineering library, or can be procured by addressing the publication directly, the address and price being given wherever possible.*

LIST OF PUBLICATIONS.

In the subjoined list of articles references are given by the number prefixed to each journal in this list.

(1) *Journal*, Assoc. Eng. Soc., 257 South Fourth St., Philadelphia, Pa., 30c.
(2) *Proceedings*, Eng. Club of Phila., 1122 Girard St., Philadelphia, Pa.
(3) *Journal*, Franklin Inst., Philadelphia, Pa., 50c.
(4) *Journal*, Western Soc. of Eng., Monadnock Block, Chicago, Ill.
(5) *Transactions*, Can. Soc. C. E., Montreal, Que., Can.
(6) *School of Mines Quarterly*, Columbia Univ., New York City, 50c.
(7) *Technology Quarterly*, Mass. Inst. Tech., Boston, Mass., 75c.
(8) *Stevens Institute Indicator*, Stevens Institute, Hoboken, N. J., 50c.
(9) *Engineering Magazine*, New York City, 30c.
(10) *Cassier's Magazine*, New York City, 25c.
(11) *Engineering* (London), W. H. Wiley, New York City, 35c.
(12) *The Engineer* (London), International News Co., New York City, 35c.
(13) *Engineering News*, New York City, 15c.
(14) *The Engineering Record*, New York City, 12c.
(15) *Railroad Gazette*, New York City, 10c.
(16) *Engineering and Mining Journal*, New York City, 15c.
(17) *Street Railway Journal*, New York City, 35c.
(18) *Railway and Engineering Review*, Chicago, Ill.
(19) *Scientific American Supplement*, New York City, 10c.
(20) *Iron Age*, New York City, 10c.
(21) *Railway Engineer*, London, England.
(22) *Iron and Coal Trades Review*, London, England.
(23) *Bulletin*, American Iron and Steel Assoc., Philadelphia, Pa.
(24) *American Gaslight Journal*, New York City, 10c.
(25) *American Engineer*, New York City, 20c.
(26) *Electrical Review*, London, England.
(27) *Electrical World and Electrical Engineer*, New York City, 10c.
(28) *Journal*, New England Water-Works Assoc., Boston, 75c.
(29) *Journal*, Society of Arts, London, England.
(30) *Annales des Travaux Publics de Belgique*, Brussels, Belgium.
(31) *Annales de l' Assoc. des Ing. Sortis des Ecôle Spéciales de Gand*, Brussels, Belgium.
(32) *Memoires et Compte Rendu des Travaux*, Soc. Ing. Civ. de France, Paris, France.
(33) *Le Génie Civil*, Paris, France.
(34) *Portefeuille Economique des Machines*, Paris, France.
(35) *Nouvelles Annales de la Construction*, Paris, France.
(36) *La Revue Technique*, Paris, France.
(37) *Revue de Mecanique*, Paris, France.
(38) *Revue Générale des Chemins de Fer et des Tramways*, Paris, France.
(39) *Railway Master Mechanic*, Chicago, Ill.
(40) *Railway Age*, Chicago, Ill., 10c.
(41) *Modern Machinery*, Chicago, Ill., 10c.
(42) *Transactions*, Am. Inst. Elec. Eng., New York City, 50c.
(43) *Annales des Ponts et Chaussées*, Paris, France.
(44) *Journal*, Military Service Institution, Governor's Island, New York Harbor, 75c.
(45) *Mines and Minerals*, Scranton, Pa., 20c.
(46) *Scientific American*, New York City, 10c.
(47) *Mechanical Engineer*, Manchester, England.
(48) *Zeitschrift des Vereines Deutscher Ingenieure*, Berlin, Germany.
(49) *Zeitschrift für Bauwesen*, Berlin, Germany.
(50) *Stahl und Eisen*, Duesseldorf, Germany.
(51) *Deutsche Bauzeitung*, Berlin, Germany.
(52) *Rigasche Industrie-Zeitung*, Riga, Russia.
(53) *Zeitschrift des oesterreichischen Ingenieur und Architekten Vereines*, Vienna, Austria.
(54) *Den Tekniske Forenings Tidsskrift*, Copenhagen, Denmark.
(55) *Ingeniören*, Copenhagen, Denmark.
(56) *Teknisk Tidskrift*, Stockholm, Sweden.
(57) *Teknisk Ugeblad*, Christiania, Norway.
(58) *Proceedings*, Eng. Soc. W. Pa., 410 Penn Ave., Pittsburg, Pa., 50c.
(59) *Transactions*, Mining Institute of Scotland, London and Newcastle-upon-Tyne.
(60) *Municipal Engineering*, Indianapolis, Ind., 25c.
(61) *Proceedings*, Western Railway Club, 225 Dearborn St., Chicago, Ill., 25c.
(62) *American Manufacturer and Iron World*, 59 Ninth St., Pittsburg, Pa.
(63) *Minutes of Proceedings*, Inst. C. E., London, England.

NOTE.—There are no references made in this month's list to German and Swedish periodicals.

LIST OF ARTICLES.

Bridge.

Northern Pacific Standard Bridge Plans.* Ralph Modjeski. (4) Feb.
Bascule Drawbridge at Chicago, U. S. A.* (12) Feb. 15.
The Concrete Bridge at Goat Island.* (14) Feb. 16.
The New Middletown Drawbridge.* H. G. Tyrrell. (27) Feb. 16.
The New Bridge Across the Rhine at Dusseldorf.* (19) Feb. 23.
An Interlocked Cast-Iron Arch Solid Floor for Bridges.* (13) Feb. 28.
The Gokteik Via luct; Burmah Railways Ltd., Burmah.* (13) Feb. 28.
A Great Swing Bridge.* (12) Mar. 1.
East River Bridge No. 3.* (15) Mar. 1.
The Brooklyn Caisson for the Manhattan-Brooklyn Bridge.* (14) Mar. 2.
Brooklyn Tower Foundation, Third East River Bridge.* (13) Mar. 7.
Floating a Drawbridge into Place.* (20) Mar. 7.
Some Odd Jobs of Foundation Work. W. A. Rogers, M. Am. Soc. C. E. (15) Mar. 8.
Moving the Hackensack River Drawbridge.* (14) Mar. 9.
Le Pont Alexandre III, à Paris.* (35) Serial beginning Nov., 1900, ending Jan., 1901.
Description du Pont Roulant sur l'Écluse Intermédiaire du Kattendijk, à Anvers.* Fr. de Winter. (30) Feb.

Electrical.

Methods of Locating Faults in Underground Electric Cables.* H. W. Fisher. (58) Dec., 1900.
European Types of High-Tension Alternators. C. F. Guilbert. (27) Serial beginning Jan. 19, ending Mar. 9.
Capacity in Alternate Current Working. W. M. Mordey. (26) Serial beginning Jan. 25, ending Feb. 8.
The Ganz System of Electric Traction.* (12) Serial beginning Jan. 25, ending Feb. 15.
A Few Notes on the Construction of Telephone Lines in Norway.* (26) Feb. 8.
Machine Tools and Outnt for Electrical Manufacturers. W. H. Booth. (26) Feb. 8.
Fulham Electricity Works.* (26) Feb. 15.
The Electric Tramway Accident at Liverpool.* (26) Feb. 15.
The Schuckert Surface Contact System.* (26) Serial beginning Feb. 15, ending Feb. 22.
Electrolysis in the District of Columbia. Grahame H. Powell. (27) Feb. 16.
Power and Light for the Machine Shop and Foundry. Prof. Forrest R. Jones. (14) Serial beginning Feb. 16, ending Feb. 23.
Dielectric Hysteresis. (26) Feb. 22.
Electric Power Plant at the Hollertszug Iron Ore Mine, Herdorf on the Sieg, Germany.* (22) Feb 22.
London County Council Slot Electric Tramways.* (12) Feb. 22.
London County Council Tramways.* (26) Feb. 22.
Measurements of Dielectric Hysteresis.* W. E. Ayrton. (26) Feb. 22.
The London County Council and Electric Tramways.* (11) Feb. 22.
Electrical Power in British Works. W. Geipel, M. I. E. E. (26) Serial beginning Feb. 22, ending Mar. 1.
The Dynamo in Recent Telephone Practice. D. M. Bliss. (26) Feb. 23.
The Independent Telephone Exchange at Rochester, N. Y. (27) Feb. 23.
Cause and Effect of Electrolytic Action upon Underground Piping Systems.* A. A. Knudson. (28) Mar.
Electric Power for Engineering Workshops: Individual and Group Driving *vs.* Long Line Shafting.* (10) Mar.
Electrical Current.* F. A. W. Davis. (28) Mar.
Rotary Transformers: Their History, Theory and Characteristics.* George W. Colles. (3) Mar.
A New Slotted Conduit.* (26) Mar. 1.
Electric Automobiles at Chislehurst. (26) Mar. 1.
Some New German Electrical Pyrometers.* (22) Mar. 1.
The Electric Lighting of the Victoria Embankment.* (26) Mar. 1.
British Transformer Practice.* (27) Mar. 2.
Development of Motor Fans. Alton D. Adams. (27) Mar. 2.
Electrical Transmission from Coal Mines.* Fred Wilson Hart. (27) Mar. 2.
Sectional Third Rail System on the Baltimore Belt Line.* (27) Mar. 2.
Some Standard Types of Ferranti Alternators and Engines.* (17) Mar. 2.
The Evolution of the Electric Sign.* E. Trier. (27) Mar. 2.
The Safety Third-Rail System on the B. & O. Tunnel.* (17) Mar. 2.
The Speed Control of Electric Motors. G. F. Packard. (20) Mar. 7.
Calculating a Battery for a Given Output.* Dr. K. Norden. (27) Mar. 9.
East Cleveland, O., Branch Telephone Exchange.* (27) Mar. 9.
The Electrical Plant at the Sneyd Collieries, England.* (10) Mar. 9.
The Slaby System of Wave-Selective Wireless Duplex Telegraphy.* (46) Mar. 9.
A Test of a Gas Engine Electric Lighting Plant.* H. N. Cheney. (24) Mar. 11.
Le Groupe Électrogène Piguet et Cie.—A. Grammont, à l'Exposition Universelle de 1900.* Paul Sarrey. (34) Feb.
Les Dynamos Schuckert au Palais de l'Électricité.* (36) Feb. 10.
La Traction Électrique sur les Grandes Lignes de Chemins de Fer et les Essais sur le Wannseebahn.* (36) Feb. 25.

* Illustrated.

Marine.

Armour-Plates at the Paris Exhibition.* M. Baclé. (11) Serial beginning Jan. 18, ending Feb. 8.
Submarine Boats. (12) Serial beginning Jan. 25, ending Feb. 15.
Shipbuilding and Marine Engineering during 1900. (12) Serial beginning Jan. 25, ending Mar. 1.
The American Submarine Boats.* Waldon Fawcett. (62) Feb. 14.
The New United States Cruisers.* (11) Feb. 15.
Steering Torpedoes by Wireless Telegraphy.* (46) Feb. 16.
Launch of a Battleship at Jarrow. (12) Feb. 22.
The New British Battleship *Russell.* (11) Feb. 22.
Importance of Economizing Tonnage Facilities by Compact Stowage of Cargoes. Henry P. Jones. (13) Feb. 28.
Equipment and Methods of the Indian Dock Yards.* A. C. Bowden. (9) Mar.
H. M. S. *Good Hope* and *Bacchante.** (12) Mar. 1.
The Holland Submarine Boat. (12) Mar. 1.
Recent Designs of Battleships and Cruisers for the United States Navy.* Rear-Admiral Philip Hichborn. (13) Mar. 7.
Propulseur Centrifuge Hydraulique pour Bateaux.* A. Dumas. (33) Feb. 2.
Le Paquebot Transatlantique *Deutschland.** S. Gradier. (33) Serial beginning Feb. 16, ending Feb. 23.

Mechanical.

Notes on Traveling Cranes.* Gerald E. Flanagan. (58) Oct., 1900.
Manufacture of Water-Gas at the Forty-fourth Street Station, New York.* (46) Serial beginning Jan. 19, ending Feb. 16.
Power Gas and Large Gas Engines. (26) Serial beginning Jan. 25, ending Feb. 15.
Some Experiences of Motor Bicycles. Joseph Pennell. (29) Feb. 8.
The Manufacture and Use of Wire Ropes.* (22) Feb. 8.
Wheel Lathe *v.* Boring Mill.* (12) Feb. 8.
Hardness or the Workability of Metals.* W. J. Keep. (47) Feb. 9.
Tests of an Experimental Locomotive Boiler. (47) Feb. 9.
Coke Ovens as Gas Works. Dr. H. Weichell (62) Feb. 14.
Engine and Generator Builders' Engine Type Units for Power Purposes. H. C. Ebert. (20) Feb. 14.
Some Notes on Central Station Heating. (20) Feb. 14.
The Fraser-Talbot Gas Producer.* (20) Feb. 14.
American Straightening, Shearing and Punching Machinery.* (22) Feb. 15.
The Belleville Boiler. (26) Feb. 15.
A New Portland Cement Mill in the Gas Fields of Kansas.* G. P. Grimsley. (16) Feb. 16.
A 1 000-Kw. Parsons Steam Turbine.* (47) Feb. 16.
The Panhard-Levassor Automobile.* (19) Feb. 16.
The Use of Blast-Furnace Gases in Gas Engines.* (19) Feb. 16.
Vanderbilt Locomotive Boiler.* (46) Feb. 16.
General Gas Works Machinery for the Philippines.* (24) Feb. 18.
Record of Rod Mills and What Has Been Accomplished. William Garrett. (62) Feb. 21.
The Hooper Pneumatic Concentrator and Drier.* (20) Feb. 21.
A New Underfeed Stoker.* (12) Feb. 22.
Babcock and Wilcox Boilers on the SS. *Martello.** (11) Feb. 22.
Kennedy's Semi-Dry Brick Press.* (11) Feb. 22.
Mica Insulation for Steam Boilers and Pipes.* (11) Feb. 22.
Petroleum Fuel for Ships: The Theory Exploded. (22) Feb. 22.
The Kaselowsky-Prott Hydraulic Pump.* Fr. Frolich. (22) Feb. 22.
Corliss-Valve Engines and Gears.* Geo. Windeler. (47) Feb. 23.
Light Lathes and Screw Machines.* John Ashford. (47) Feb. 23.
West's Improved Machine for Charging Retorts.* (24) Feb. 25.
An Economical Steam Power Plant and What It Teaches. Geo. H. Barrus. (10) Mar.
Continental Steam Engines as Seen at the Paris Exhibition.* W. D. Wansbrough. (10) Mar.
Economy in Fuel Combustion and Steam Generation. William Wallace Christie. (9) Mar.
Heating from Central Stations—A Comparison with Private Heating Plants. Alton D. Adams. (60) Mar.
Late Practice in Utilising Blast Furnace Gas as a Gas Engine Fuel.* William H. Booth, M. Am. Soc. C. E. (10) Mar.
Soldering Aluminium. Joseph Allison Steinmetz. (10) Mar.
The New Plant of the Franklin Air Compressor Co.* (15) Mar. 1.
The Rock Drill.* (22) Mar. 1.
The Kress Aeroplane.* (46) Mar. 2.
The Stirling Water-Tube Boiler.* (47) Mar. 2.
Gas Lighting at the Paris Exposition. Walter S. Allen. (24) Mar. 4.
Remarks on Gas Purification.* S. J. Fowler. (24) Mar. 4.
Flywheel Explosions. Charles H. Manning. (13) Mar. 7.
Some Interesting Troubles with Gas Engines. Albert Stritmatter. (62) Mar. 7.

* Illustrated.

Mechanical—(Continued).

An Improved Gasoline Automobile.* (46) Mar. 9.
Some Sketches of Gas Governors.* J. J. Humphreys, Jr. (24) Mar. 11.
Les Ascenseurs à l'Exposition de 1900.* P. Dumesnil. (33) Serial beginning Jan. 19, ending Feb. 2.
Engrènement des Vis et Roues Héliçoïdales avec Profils Suivant une Developpante de Cercle à Cycloïde et Son Influence sur la Durée des Engrenages.* (37) Jan. 31.
Utilisation des Gaz de Hauts Fourneaux et de Fours à Coke. E. Deschamps. (37) Jan. 31.
Essais de Moteurs à Gaz et de Gazogènes à la Station Centrale à Gaz Pauvre des Tramways de Cassel, prés Dunkerque (Nord).* (33) Feb. 23.
Appareil Ripper pour Apprécier à Chaque Instant le Travail d'un Moteur à Vapeur.* (36) Feb. 25.

Metallurgical.

A Modern American Blast Furnace.* Arthur C. Johnston. (1) Jan.
The British Columbia Copper Company's Smelting Works at Greenwood, B. C.* Paul Johnson. (16) Feb. 16.
Notes on Tuyeres.* John M. Hartman. (20) Feb. 21.
American Steel and Wire Company's New Blast Furnace at Neville Island.* Christian Larsen. (62) Feb. 28.
Centrifugal Casting.* A. E. Fay. (20) Feb. 28.
Chlorination Mills at Cripple Creek, Colorado.—The Methods Used in Handling the Ore and the Application of the Process.* Prof. Arthur Lakes. (45) Mar.

Military.

A Brief Sketch of the Essential Requisites of "Powder" as Distinguished from Explosives. Dr. W. J. Williams. (3) Mar
Nordenfelt's Quick-Firing Field Artillery.* (11) Mar. 1.
The Manufacture of American Ordnance.* Waldon Fawcett. (62) Mar. 7.
Inconvénients du Béton de Ciment Armé dans la Construction des Ouvrages de Fortification. Adrien Hallier. (33) Feb. 9.

Mining.

Winding from Great Depths.* (12) Serial beginning Mar. 16, 1900, ending Feb. 22, 1901.
Hydraulic Excavation. Latham Anderson. (1) Jan.
The South Hetton Coal Company's Collieries and Their Equipment.* (22) Serial beginning Feb. 1, ending Feb. 15.
The Testing of Winding Ropes in the Province of Anhalt, Germany. Frank H. Probert. (13) Feb. 14.
Coal Mine Foremen and Labor-Saving Devices. L. C. Morganroth. (16) Serial beginning Feb. 16, ending Feb. 23.
Mining Practice at Rossland, British Columbia.* R. B. Brinsmade. (45) Mar.
The Windber Mine: A Description of the System of Underground Haulage and Mining Methods as Installed and Used. J. S. Cunningham. (45) Mar.
Wire Ropes. J. T. Beard. (45) Mar.
Hoisting from Deep Shafts.* Leon Poussigue. (16) Mar. 9.
L'Exploitation des Mines à l'Exposition de 1900.* H. Schmerber. (33) Serial beginning Feb. 2, ending Feb. 23.

Miscellaneous.

Engineering Opportunities in Central and Southwestern Asia.* Alexander Hume Ford (9) Mar.
Influence of the Exposition on the French Iron and Steel Industry. Henri Guérin. (9) Mar.
The Outlook of the World's Timber Supply. Dr. W. Schlich. (29) Mar. 1.

Municipal.

Street Lighting of Cities.* Henry H. Humphrey. (1) Jan.
The Renovation of Havana.* (14) Serial beginning Jan. 19, ending Feb. 16.
The New Road from Enzeli to Teheran.* (12) Serial beginning Feb. 1, ending Feb. 15.
Municipal Electric Lighting in Chicago. Edward B. Ellicott. (14) Feb. 23.
Comparison of Cost of Asphalt Pavements. (60) Mar.
Landscape Problems in the Improvement of Spot Pond Reservoir, Metropolitan Water-Works.* Frederick Law Olmsted, Jr. (28) Mar.
Repairing Asphalt Pavements in Chattanooga * Robt. Hooke. (60) Mar.
The Block Asphalt Pavements of Pontiac, Mich. William J. Fisher. (60) Mar.
Municipal Improvements at Chattanooga, Tenn.* (13) Mar. 7.

Railroad.

Hot Driving Boxes on Locomotives. M. E. Wells. (61) Jan.
Hydrostatic Tools in Railway Service.* George L. Gillon. (61) Jan.
Heavy Motor Traffic in France. George Forestier. (47) Serial beginning Jan, 12, ending Jan. 19.
A Large Roundhouse at Clinton, Ia.; Chicago and Northwestern Ry.* (13) Feb. 14.

* Illustrated.

Railroad—(Continued).

A Typical Suburban Service: How the Chicago and Northwestern Carries the Rural Residents to and from Chicago. (40) Feb. 15.
Railway Couplings.* (11) Feb. 15.
Readville Car Shops—New York, New Haven and Hartford.* (15) Feb. 15
The Hudson River Railroad.* Herbert T. Walker. (15) Feb. 15.
Construction of the East Boston Subway and Tunnel.* (18) Feb. 16.
New Hopper Coal Cars on the Northern Pacific Ry.* (18) Feb. 16.
The Illinois Central Semi-Centennial.* (18) Feb. 16.
Finishing Temperatures for Steel Rails.* Robert W. Hunt. (20) Feb. 21.
Stadia Surveys for Railway Location. H. P. Boardman. (13) Feb 21.
A Novel Electric Railway.* (26) Feb. 22.
Some Features of Railway Travelling, Past and Present. Frederick McDermott. (29) Feb. 22.
The Growth of the Illinois Central. J. T. Harahan. (40) Feb. 22.
The Price Patent Friction Brake.* (26) Feb. 22.
70 000-lb. Capacity Box Cars for the Northern Pacific Ry.* (18) Feb. 23.
Some Engineering Features of the Grand Central Station, New York.* (14) Feb. 23.
Some Features of Railway Tunnel and Subway Construction. (18) Feb. 23.
A Model Oil House, Chicago and Northwestern Railway.* (39) Mar.
Actual Working of American Locomotives on British Railways.* Charles Rous-Marten. (9) Mar.
Compound Consolidation Freight Locomotives, with Wide Firebox, New York Central and Hudson River Railroad.* (25) Mar.
Express Passenger Engines: Madras Railway.* (21) Mar.
New Car Shops, New York, New Haven and Hartford Railroad, at Readville, Mass.: Details of the Buildings.* (25) Mar.
Safety Appliances in the United States. (39) Mar.
70 000 Pounds Capacity Flat Car, Northern Pacific Railroad.* (39) Mar.
The New Class "J" Passenger Locomotive of the Lake Shore and Michigan Southern Railway.* (25) Mar.
The Use of Liquid Fuel in Locomotives.* James Holden. (39) Mar.
French Rolling-Stock at the Paris Exhibition. (11) Mar. 1.
Further Economies in Coal and Ore Handling.* John M. Goodwin. (15) Mar. 1.
"Manibills" for Waybills in Freight Traffic. (40) Mar. 1.
The Cascade Tunnel on the Great Northern Railway, U. S. A.* (12) Mar. 1.
Foreign Locomotives at the Exposition of 1900.* (19) Mar. 2.
London's First Electric Tramway.* Frederick A. Talbot. (17) Mar. 2.
New Power Station and Elevated Railway System in Boston.* (17) Mar. 2.
Notes on the City and Suburban Railway, Portland, Ore.* (17) Mar. 2.
Snow Fence. (18) Mar. 2.
Some Recent Electric Railway Construction for San Francisco.* S.L. Foster. (17) Mar. 2.
Street Car Hoods or Canopies.* W. E. Partridge. (17) Mar. 2.
The Street Railway System of Lisbon.* F. A. Wardlaw. (17) Mar. 2.
Two Interesting Schenectady Locomotives.* (18) Mar. 2.
Difficult Earthwork Construction on the Copper Range R. R.* (13) Mar. 7.
The Quality of Steel for Rails. (13) Mar. 7.
Certain Considerations in Designing Yards. W. L. Derr. (15) Mar. 8.
Freight Yards of the Chicago Transfer & Clearing Co.* (15) Mar. 8.
Handling Locomotive Coal on the New York Central.* (15) Mar. 8.
How to Study the History of a Rail.* Stephen W. Baldwin. (15) Mar. 8.
Pneumatic Interlocking at Wayne Junction.* (15) Mar. 8.
Preservation of Sleepers in England and Continental Countries.* P. H. Dudley. (15) Mar. 8.
The Engineering Department of the New York Central.* (15) Mar. 8.
The Oiled Roadbed on the Long Island Railroad. C. L. Addison. (15) Mar. 8.
The Personnel, Material and Methods of a Railroad. L. F. Loree. (15) Mar. 8.
Tunnels on the West Virginia Short Line Railroad.* J. V. Davies. (15) Mar. 8.
Uniform Track Structure.* M. W. Thomson. (15) Mar. 8.
Ventilation of the East Mahanoy Tunnel—Philadelphia & Reading.* Theodore Voorhees. (15) Mar. 8.
Electric Traction for Heavy Railroad Service. (17) Mar. 9.
The Progress of the Siberian Railway.* (19) Mar. 9.
L'Exposition Universelle de 1900: Notice sur le Matériel et les Objects Exposés par la Compagnie des Chemins de Fer du Midi.* (38) Jan.
Les Locomotives Hongroises à l'Exposition de 1900. Raymond Godfernaux. (38) Jan.
Les Locomotives Allemandes à l'Exposition.* Daniel Bellet. (36) Serial beginning Jan. 25, ending Feb. 10.
Appareils pour la Manœuvre Électrique des Signaux et des Aiguilles: Système Siemens et Halske.* René Philippe. (34) Feb.
Les Locomotives à l'Exposition de 1900: Locomotives Compound Express à 2/4 Essieux Accouplés des Chemins de Fer du Nord-Est et du Central Suisses.* F. Barbier. (33) Feb. 2.
Le Chemin de Fer à Plans Inclinés Mobiles.* Albert Reyner. (36) Feb. 25.
Locomotive à Grande Vitesse des Chemins de Fer de l'État Prussien, avec Surchauffeur de Vapeur (Système Wilhelm Schmidt).* A. Morizot. (36) Feb. 25.

* Illustrated.

Sanitary.

"Airedale" Feed-Water Heater.* (47) Feb. 9.
Cleaning a Large Brick Sewer in Hartford, Conn. Frederick L. Ford. (14) Feb. 16.
The Septic Tank Experiments at Pawtucket.* (14) Feb. 16.
Ventilation and Heating of the American Exchange National Bank, New York.* (14) Feb. 16.
Garbage as Fuel for Steam Production. W. L. Hedenburg. (60) Mar.
The Bacterial Self-Purification of Streams. (19) Mar. 2.
Ventilating and Heating the Boston Music Hall.* (14) Mar. 2.
The Shelby, Ohio, Sewerage System.* J. B. Weddell. (14) Mar. 9.
Ventilation and Heating in a Paterson, N. J., Schoolhouse.* (14) Mar. 9.

Structural.

The New Plant of the Curtis Publishing Co.* Charles Henry Davis and John S. Griggs, Jr. (14) Serial beginning Feb. 23, ending Mar. 9.
Concrete Mixing and Depositing Machine.* (13) Feb. 28.
A Discussion of Recent Developments in the Fireproofing of Wood.* Joseph L. Ferrell. (3) Mar.
American Slag Cements. William Kendrick Hatt. (14) Mar. 2.
Boyer Machine Company's Plant at Detroit.* (40) Mar. 8.
The Cramp Machine Shop and Power House.* (14) Mar. 9.
Les Emplois de La Lave de Volvic dans l'Industrie.* M. Seurat. (33) Feb. 9.

Topographical.

American Mine Surveying Instruments.* (22) Feb. 8.
Controlling a Topographical Survey. Wm. C. Bunnel. (13) Feb. 14.
Geodesy. Wilfrid Airy, M. Inst. C. E. (11) Feb. 15.

Water Supply.

Water Power by Direct Air Compression. William O. Webber. (1) Jan.
Notes on Designing and Constructing Slow Sand Filters. James H. Fuertes, M. Am. Soc. C. E. (14) Serial beginning Jan. 26, ending Feb. 9.
The Evolution of the Oxygen Absorption Test in Water and Sewage Analysis. Prof. J. W. Weems. (14) Serial beginning Jan. 26, ending Feb. 9.
The Bridgeport Wheel Pumps.* Ossian Guthrie (4) Feb.
Tunnel and Crib Construction in Chicago.* Paul G. Brown. (4) Feb.
The Arad Water-Works and Fischer Plate Filters.* (11) Feb. 15.
Ingenious Water-Wheels.* Waldon Fawcett. (46) Feb. 16.
The New Wheelpit of the Niagara Falls Power Company.* (14) Feb. 16.
Removal of Iron from the Water Supply of Superior, Wis.* R. D. Chase, Assoc. M. Am. Soc. C. E. (13) Feb. 21.
The Water-Power Plant at Massena, N. Y.; St. Lawrence Power Co.* (13) Feb. 21.
An Inexpensive Gage for use with the Venturi Meter.* Charles P. Paulding. (13) Feb. 28.
Removal of Some Submerged Water Mains at Chelsea, Mass.* Caleb Mills Saville, Assoc. M. Am. Soc. C. E. (13) Feb. 28.
A Report on Trial of 30 000 000 Gallon Pumping Engine at the Chestnut Hill High-Service Station of the Metropolitan Water-Works, made May 1 and 2, 1900. Will J. Sando. (28) Mar.
Stand Pipes and Elevated Reservoirs.* George S. Pierson. (60) Mar.
Subterranean Waters. Charles Morris. (3) Mar.
The Purification of the Washington Water Supply. Rudolph Hering, George W. Fuller and Allen Hazen. (14) Mar. 2.
Étude sur la Solubilité du Sulfate de Chaux.* M. Boyer-Guillon. (37) Jan. 31.
Usine Hydro-Électrique du Saut-Mortier: Création de la Chute sur l'Ain.* J. Claudet. (33) Feb. 9.

Waterways.

Design for a Controlling Works at the Chicago End of the Drainage Canal.* Ossian Guthrie. (4) Feb.
The Improvement of the Chicago River. (4) Feb.
Sea-Going Hydraulic Dredges for the East Channel Improvement, New York Harbor.* (13) Feb. 14.
Shall a Canal be Built from the Lakes to the Sea? William G. Raymond. (15) Feb. 15.
Beard's Contour System of Groynes.* (11) Feb. 22.
Conneaut Harbor Ore Docks.* (15) Feb. 22.
Powerful Nine-Ton Dipper Dredge.* (46) Feb. 23.
A Large Single-Rope Dipper Dredge.* (13) Feb. 28.
The Port of London. W. H. Wheeler, M. Inst. C. E. (12) Mar. 1.
Metal Casing for Light-House Tower at Grande Pointe au Sable.* (14) Mar. 2.
Drilling and Blasting Submerged Rock. (14) Mar. 9.
Le Maréosiphon: Appareil Automatique de Préservation Contre les Inondations de Marée.* G. Willems. (30) Feb.
Les Nouvelles Installations Maritimes du Port d'Ostende.* A. Cadola. (30) Feb.
Le Port de Naples.* C. de Cordemoy. (36) Feb. 25.

---

* Illustrated.

NEW BOOKS OF THE MONTH.

Unless otherwise specified, books in this list have been donated to the Library by the Publisher.

SURVEYING AND LEVELLING INSTRUMENTS

Theoretically and Practically Described for Construction, Qualities, Selection, Preservation, Adjustments and Uses; with other Apparatus and Appliances used by Civil Engineers and Surveyors in the Field. By William Ford Stanley. Third Edition. London, E. & F. N. Spon, 125 Strand; New York, 12 Cortlandt St., 1901. Cloth, 8 x 5 ins., 562 pp., illus. $3. (Donated by the Author.)

In this edition the author has endeavored, as far as practicable, to take advantage of the many suggestions offered by professional men since the first publication of the work. The Contents are: Introduction; The Telescope as a Part of a Surveying Instrument; The Magnetic Compass as a Part of a Surveying Instrument or Separately; Levels; Levelling Staves; Division of the Circle and Methods Employed in Taking Angles; Theodolites; Specialties in Modern Forms of Transit; Plain Theodolites in Which the Transit Principle is not Employed; Large Theodolites Used only for Geodetic Surveys; Mining Survey Instruments; Instruments to Measure Subtense or Tangential Angles to Ascertain Distances; Instruments Constructed Especially for Facility of Taking Inclinations; Instruments of Reflection; Graphic Surveying Instruments and Appliances Connected Therewith; Instruments for Measuring Land and Civil Works Directly; Stations of Observation; Measurement of Altitudes by Differences of Atmospheric Pressure; Miscellaneous Surveyors' and Engineers' Instruments, Appliances and Accessories. There is an index of five pages.

SCHERZER ROLLING LIFT BRIDGES.

An Illustrated Description of Rolling Lift Bridges as Erected by the Scherzer Rolling Lift Bridge Company. By Albert H. Scherzer. Cloth, 11 x 14 ins., 67 pp., 23 plates. Chicago, 1901. $10. (Donated by Albert H. Scherzer.)

This is a description of rolling lift bridges and an explanation of the relative advantages of bascule bridges as compared with swing spans. There is also a discussion of the advantages of bridges of the rolling lift type over those with pivots.

DONATIONS TO THE LIBRARY.

FROM FEB. 14TH, 1901, TO MARCH 13TH, 1901.

Am. Soc. for Prevention of Cruelty to Animals. 1 pam.
Am. Soc. of Mech. Engrs. 1 bound vol., 1 pam.
Atchison, Topeka & Santa Fé Ry. Co. 1 pam.
Baltimore & Ohio R. R. Co. 5 pam.
Belzner, Theodore. 1 pam.
Berlin Königliche Technische Hochschule. 1 bound vol.
Black, W. M. 1 vol.
Bond, Edward A. 1 vol.
Boston & Albany R. R. Co. 2 pam.
Boston & Maine R. R. Co. 12 pam.
Brünn K. K. Technischen Hochschule. 1 bound vol.
Cornell Univ. 1 pam.
Croes, J. J. R. 6 bound vol., 107 pam.
Dauchy, W. E. 9 pam.
Eng. Assoc. of the South. 1 vol.
Engrs. Soc. of Western Penna. 1 pam.
Ewald, Frank G. 2 bound vol.
Fisher, E. A. 1 vol.
France-Ministère des Travaux Publics. 2 vol.
Fulton, D. L. 5 vol.
Gemmell, R. C. 1 pam.
Hodgdon, Frank W. 1 bound vol.
Hunt, W. T. 1 bound vol.
Hutton, N. H. 7 pam., 4 phot.
Inst. of Engrs. of the River Plate. 1 pam.
Japan-Imperial Earthquake Investigation Com. 2 vol.
Lawton, Wm. H. 2 maps.
Leutzé, Trevor McC. 1 bound vol.
Lewis, N. P. 5 bound vol., 2 vol.
Liverpool Eng. Soc. 1 vol.
Martin, Wisner B. 3 bound vol., 1 pam.
Merchants' Assoc. of New York. 1 pam.
Mich. Univ. 1 pam.
Moncrieff, A. B. 4 vol.
Moore, Charles. 1 bound vol.
N. Y. State Board of R. R. Commrs. 2 bound vol.
N. Y. State Univ. 1 vol.
Ontario-Provincial Board of Health. 1 bound vol.
Platt, T. C. 9 pam.
Roadmasters' Assoc. of Amer. 1 pam.
St. Louis Merchants' Exchange. 1 vol.
Scarborough, F. W. 5 pam.
Scherzer, Albert H. 1 bound vol.
Schrenk, Hermann von. 1 pam.
Stanley, William Ford. 1 bound vol.
Sublette, G. W. 1 pam.
U. S. Bureau of Education. 1 bound vol.
U. S. Corps of Engrs. 4 bound vol.
U. S. Dept. of Agriculture. 1 pam.
U. S. Geological Surv. 4 maps.
U. S. Treasury Dept. 1 vol.
Wanier, A. G. 45 bound vol., 17 vol.
Unknown Donor, 1 pam.

MEMBERSHIP.

ADDITIONS.

MEMBERS.

		Date of Membership.
Baier, Julius,	Jun.	Sept. 7, 1887
Asst. Man. and Eng., Conrey Placer Mining Co , Virginia City, Madison Co., Mont.....	Assoc. M.	June 1, 1892
	M.	Feb. 6, 1901
Chester, John Needels,	Jun.	Dec. 6, 1892
600 Lewis Blk., Pittsburg, Pa..	Assoc. M.	Dec. 5, 1894
	M.	Mar. 6, 1901
Smith, Leonard Charles Lindsay,		
59 Woolsey St., Astoria, Long Island City, N. Y.....		Mar. 6, 1901
Strong, Mason Romeyn,		
Bridge Eng., Erie and N. Y., Susq. & Western R. Rds., 237 Lexington Ave., Passaic, N. J.....		Mar. 6, 1901

ASSOCIATE MEMBERS.

Bishop, William Israel,		
40 McGill College Ave., Montreal, Que., Canada.....		Feb. 6, 1901
Carlile, Thomas Jenks,	Jun.	Mar. 3, 1896
4215 Chestnut Street, Philadelphia, Pa.....	Assoc. M.	Mar. 6, 1901
Fickes, Edwin Stanton,		
Care, Pittsburg Reduction Co., Pittsburg, Pa	Jun.	Jan. 4, 1898
	Assoc. M.	Feb. 6, 1901
Fox, Walter Gordon,		
Asst. Eng., Guayaquil & Quito Ry., Guayaquil, Ecuador.		Jan. 2, 1901
Lyon, Wallace Chittenden,		
Care, Supervising Architect's Office, Treasury Dept., Washington, D. C		Feb. 6, 1901
Reynolds, Justin Oakley,	Jun.	Oct. 6, 1896
2006 Washington Ave., New York City.....	Assoc. M.	Dec. 5, 1900

ASSOCIATES.

Kelley, James Augustus,		
1921 Dennie St., Philadelphia, Pa		Mar. 5, 1901
Tenney, George Oliver,	Jun.	Sept. 7, 1887
Contractor, Spartanburg, S. C.....	Assoc.	Feb. 5, 1901

JUNIORS.

Carpenter, Allan Wadsworth,	
Asst. Eng., N. Y. C. & H. R. R. R., 502 Grand Central Station, New York City.....	Mar. 5, 1901
Corrigan, George Washington,	
Harrisonville, Mo.....	Feb. 5, 1901

	Date of Membership.
DE LA MORA, MANUEL, Ap. 319, Guadalajara, Mexico	Dec. 28, 1900
DOUGAN, JAMES, 453 West 19th St., New York City	Mar. 5, 1901
GIFFORD, HARRY VAN VLECK, 2127 Monroe St , Toledo, Ohio	Mar. 5, 1901
NUTTER, CHARLES HERBERT, 144 Lexington Ave., New York City	Feb. 5, 1901
SPENCER, LOUIS BERNARD, 2555 Jefferson Ave., Ogden, Utah	Oct. 31, 1899
WELLS, CLINTON GLENCAIRN, Electrical Com. of Baltimore, Office of Chf. Eng , Baltimore, Md	Mar. 5. 1901

DEATHS.

HISLOP, JOHN.....Elected Member May 1st, 1895; died Feb. 22d, 1901.

HOWELL, GEORGE WASHINGTON.....Elected Member May 2d, 1888; died Feb. 15th, 1901.

PENNYPACKER, LEVIS PASSMORE.....Elected Associate Member Apr. 1st, 1891; died Jan. 30th, 1901.

RUSLING, GEORGE MCCRACKEN.....Elected Member Nov. 1st, 1882; died Feb. 26th, 1901.

TASKER, STEPHEN PASCHALL MORRIS..Elected Fellow Sept. 20th, 1872; precise date of death not known.

Vol. XXVII, MARCH, 1901. No. 3.

AMERICAN SOCIETY OF CIVIL ENGINEERS.

INSTITUTED 1852.

PAPERS AND DISCUSSIONS.

NOTE.—This Society is not responsible, as a body, for the facts and opinions advanced in any of its publications.

CONTENTS.

Discussions on Papers which have been presented: PAGE

The Theory and Practice of Precise Spirit Leveling.
By DAVID A. MOLITOR, M. Am. Soc. C. E. 126

The Adjustment of a Transit Survey as Compared with that of a Compass Survey.
By Messrs. J. H. FUERTES, W. H. LUSTER, Jr., and W. B. LEE 150

The Construction of Gravity Sand Filters at Nyack, N. Y.
By Messrs. JAMES S. HARING, J. H. FUERTES, G. KAUFMAN and MORRIS KNOWLES 156

Discussions on Topics presented at the Convention:

Filtration of Water for Public Use.
By Messrs. GUSTAV HEINKE and NICHOLAS SIMIN 164

Memoirs of Deceased Members:

EDWARD ARNOLD CORREA, M. Am. Soc. C. E. 169
WILLIAM GIDDINGS CURTIS, M. Am. Soc. C. E. 172
RANDELL HUNT, M. Am. Soc. C. E. 175
NILES MERIWETHER, M. Am. Soc. C. E. 178
MARC JOHN REISEGER, M. Am. Soc. C. E. 180
WILLIAM HOWARD WHITE, M. Am. Soc. C. E. 181
JOSEPH RUGGLES RICHARDS, Assoc. Am. Soc. C. E. 183
JOHN MONTGOMERY TOUCEY, F. Am. Soc. C. E. 187

Vol. XXVII. MARCH, 1901. No. 3.

AMERICAN SOCIETY OF CIVIL ENGINEERS.
INSTITUTED 1852.

PAPERS AND DISCUSSIONS.

NOTE.—This Society is not responsible, as a body, for the facts and opinions advanced in any of its publications.

THE THEORY AND PRACTICE OF PRECISE SPIRIT LEVELING.

Discussion.*

By DAVID A. MOLITOR, M. Am. Soc. C. E.

Mr. Molitor. DAVID A. MOLITOR, M. Am. Soc. C. E. (by letter).—The writer is greatly indebted for the facts and opinions expressed by those who have participated in the discussion of his paper on Precise Spirit Leveling. It is significant, however, that the men of wide and varied field experience have not taken the initiative, but have left the discussion principally to those who have never done any extensive precise leveling themselves, and whose connection with the subject is generally limited to the study of work done by others. It is difficult to understand this, unless it would indicate that the criticisms offered are on theoretical and prejudicial rather than on practical lines.

In many instances, errors, which are scarcely to be avoided in a paper of such length, have been pointed out, and for this the writer feels very grateful. Also, many unnecessary comments have been made, as a result of superficial reading of the paper, a feature common to most discussions.

As stated in the "Introductory" of the paper, it was the writer's object to give a comprehensive treatise on the subject chosen. To do this necessitated mentioning all possible sources of error, and deducing a method of practical field work, which would give the most accurate results attainable. This, the writer considers he has done, but, to infer therefrom that he would advocate following his method for all purposes and under all circumstances is entirely unreasonable.

*Continued from January, 1901, *Proceedings*. See September, 1900, *Proceedings* for paper on this subject by David A. Molitor, M. Am. Soc. C. E.

Mr. Molitor.

It is likewise unjust to offer the criticism that the paper is too theoretical and voluminous, considering the simplicity of the subject. The subject is simple only to those who have not fathomed its depths.

The fact that very good work may be done with single sights (without bubble reversals and telescope inversions) is known to the writer as well as to those who criticise him for not having chosen this simpler programme of leveling. Where the highest attainable accuracy is required, however, the same reasons which compelled him to abandon the older methods, and which are fully set forth in the paper, may at some time cause a similar change in the methods still used by others.

The writer's conception of the term "Precise Spirit Leveling" is, not to run the greatest number of miles of levels for the least money, but to do the most accurate work possible at a reasonable cost.

Everyone is at liberty to simplify the general method advocated for the achievement of the most accurate work to any extent suitable for a given purpose, but to do this intelligently a complete knowledge of the subject is essential, otherwise the short cuts may prove very disastrous, even for work of ordinary quality.

The scope of the paper is very broad, and is intended to point out the manner of increasing the accuracy of all level work, of whatever class, by applying to common levels such features of the precise methods as may be accepted without material increase in cost. These are: Equalization of sights; use of an umbrella; use of self-reading instead of target rods; to have on the instrument a level tube (with mirror) which may be used as a striding or fixed level at will; and to supplant the rigid wyes with swinging wyes, thus doing away with the wye adjustment of the common level. A further addition of value to the instrument would be a watch-glass level for approximate setting up. All this may be had at a small additional first cost, and may be used without any material increase in expense, while the advantages gained would surprise the most skeptical leveler.

For ordinary work, it would not be necessary to read more than the middle thread, or to use more than one instrument position. Sights up to 300 m. would be possible for a magnifying power of 40 diameters, and a 6 seconds per 2 mm. level tube.

The writer has done some work of this class at a rate of a mile in 35 minutes, with an error in millimeters of not more than $5\sqrt{\frac{L}{2}}$. However, the roads and atmospheric conditions permitting of such work were far better than the average, and these figures are cited merely to distinguish between common and precise levels, even though lines run in this manner frequently close with ridiculously small errors.

On the writer's line of levels along the St. Lawrence River, the average length of shot was 49 m., and single shots varied from 6 to

Mr. Molitor. 80 m. The practical limit was determined by the profile of the line, and no increased rapidity would have been attainable even if long shots had been permissible.

It has been demonstrated quite conclusively that long lines of common levels can be run with comparatively small discrepancies, compared with precise level work, though this is due to a compensation of errors which, for short stretches, might be surprisingly large. For precise level work, any portion of a line must be as accurate as the entire line, and to accomplish this is quite a different problem from obtaining an accidental small closure at the end of a long line of common levels.

On the other hand, many lines of so-called precise levels have shown cumulative errors which, for a long line, would give poorer closures than lines of good common levels. Hence, the methods certainly are responsible for much of this, and when a certain accuracy, excelling that attainable by perfection of methods and instruments, is required, it must be obtained by a repetition of observations. The writer has introduced this latter refinement to the extent which is considered practical.

Several of the discussors have taken exception to the writer's method of observing, and Mr. J. A. Ockerson says for "the trained observers on this work" that they would hesitate in accepting it. It might have been as well to have allowed the "trained observers" to express their own views, and facts from this source would have been far more valuable than opinions. The principal objection is stated to be the increased lapse of time between back and fore sight readings, which it is claimed is twice as long as for the method without reversals, etc.

A careful reading of the paper (bottom of page 863*), the substance of which is repeated in other places, would have avoided the necessity for the present comments. The above-mentioned paragraph shows clearly that the time interval between each pair of back and fore sight readings (during which no reversals, etc., are made) is exactly as in the commonly adopted method. The instrument positions are changed after taking the first pair of sights and before taking the second pair, which latter sights are read in reverse order. This virtually constitutes a direct and reverse line between successive turning points, without increasing the time interval between successive back and fore sights, while the four readings furnish the data for a single line only.

When, therefore, the atmospheric conditions or refractive changes become so severe that duplicate pairs of sights are prohibitive, then the same will be true of a single pair of sights, though this fact is not observable for single sights until a stretch is closed. With dupli-

* *Proceedings*, September, 1900.

cate pairs of sights such deleterious influences are immediately detected by mere inspection of the notes. In this way it frequently happens that work which has been good up to a certain point can be saved by suspending operations as soon as the conditions are seen to become unfit. This can always be done when the steel turning point pins are used. Mr. Molitor.

A further advantage of duplicate sights is the almost infallible check on the correctness of the readings which the recorder exercises by mere inspection (a feature which Mr. Marshall calls distinctly bad), and the additional accuracy in reading and pointing derived from two observations.

Mr. Hayford further states that the writer's method requires reversing the striding level twice and inverting (wrongly reversing) the telescope twice at each station. Apparently, this is not the case, and precludes the necessity for the further argument that "the more an instrument is handled, the less accurate are the results obtained." While the truth of this argument is freely granted, the question here is essentially one of repetition of observations, and not of handling the instrument.

To deny the foregoing statements of fact would be equivalent to asserting that the mean of two or more observations is not as good as a single one. The repetition of observations on triangulation and astronomical work is scarcely more justifiable than in the case of precise leveling.

The practical value of the writer's method may be further illustrated by the following: The level line St. Regis-Oak Point, Table No. 21, with a probable error of $\pm$ 0.61 mm. per kilometer, on which a slightly different programme of reading was used, necessitated re-running 10% of the work, in order to fulfil the specification $3\sqrt{L}$, while, with the same limit and using the method advocated in the paper, the line Oak Point-Tibbetts Point gave a probable error of only $\pm$ 0.48 mm. per kilometer, and not a single stretch failed to close on the first pair. No such record as this has ever been cited in support of the value of a method, and it might be well for the "trained observers" and others of less training, to give this method an impartial trial before casting it aside with a few prejudicial remarks.

Regarding the question of rapidity and cost, it will be seen, presently, that the writer's method of duplicate readings does not retard the work nearly as much as might be supposed.

For an average length of sight of 50 m., working 7 hours per day and counting 22 days per month for actual work, the average rate of progress was 100 km., or 63 miles, of single line per month, which, for the wages paid, would aggregate $10 per kilometer, or $16 per mile, of double line, as per Table No. 24, for the Lake St. Clair levels, where the cost includes all expenses of every description. The same work

Mr. Molitor. showed a probable error of $\pm$ 0.33 mm. per kilometer, and the allowable limit was $3\sqrt{\frac{L}{2}}$. Had the weather conditions been more favorable, thus permitting of longer sights (as the ground was quite level), this work could easily have been accelerated from 30 to 50 per cent. But, taking the figures as they stand, they compare very favorably with any of those cited in the discussion for levels where the single sights were used and work was carried on throughout the day.

It should be noted that confining the work to the early and late hours of the day does not necessarily mean a reduction in working hours and consequent increase in cost, as Mr. Hayford supposes.

This matter can be justly dealt with only when all the influencing factors are accurately known, especially the wages paid, allowable limit of closure, kind of territory covered, working hours, etc. The figures given in Tables Nos. 23 and 24 are actual, while those given by Mr. Hayford, on average rapidity, are, to some extent, estimated; and the extraordinary cases, while interesting, are not representative.

The levels by the Geological Survey are hardly comparable with those of the Coast and Geodetic Survey or those of the Engineer Corps, U. S. A., for very evident reasons. It cannot be expected that the most accurate work can be done as cheaply as that done under much less rigid specifications.

The figures cited by Mr. Hayford for cost of recent Coast and Geodetic Survey work show no greater economy than those produced by the writer. The difference in cost is readily explained by the longer sights permitted under the Coast and Geodetic Survey, a fact decidedly against the production of high-class work. The cost of bench-marks may also vary from almost nothing to perhaps $10 each. On the writer's Lake St. Clair levels, the cost of bench-marks was not separated, and Mr. Hayford incorrectly assumed it to be the same for the St. Lawrence River line.

The comparative figures for cost per mile of double line then stand as in Table No. 33.

TABLE No. 33.

Coast and Geodetic Survey.		Mississippi and Missouri River Commissions.		The Writer's Levels.	
Wyoming, 1899	$17.00	Carrollton-Biloxi, 1882	$31.93	St. Lawrence River*	$22.00
Ohio	14.00	Keokuk-Fulton, 1882	19.08	Lake St. Clair	17.44
Nebraska and Kansas, 1899	11.00	Blair, Neb.-Dewitt, Mo., 1893	23.00		
		1 000 miles, Missouri River, 1894	20.00		
Work prior to 1899 was much more expensive, being nearly double the above figures		New Orleans-Biloxi, 1900	15.50		
		St. Paul-Aitkin, "	12.65		
		Brainerd-L. Itasca, Cass Lake-Grand Rapids, 1900	15.25		

* Wages about as given on page 896, or 20% higher than for Lake St. Clair levels.

Mr. Molitor.

The theoretical relation between rapidity and accuracy for two lines of levels, supposing both to be on an economical basis, is that the accuracies shall be proportional to the square roots of the rapidities. The best Coast and Geodetic Survey work was done at the rate of 63 miles per month, and the Lake St. Clair levels at the rate of 31 miles per month. Hence the accuracies should be as $\sqrt{63} : \sqrt{31}$, or 8 : 5.6. The actual relation is 8 : 4, or decidedly in favor of the Lake St. Clair levels.

Table No. 34 may add some comparative data on rapidity not yet exhibited. For other data relative to these lines, see Table No. 21.

TABLE No. 34.—Rapidity of Precise Level Work.

Time of running single line by single party.

Items.	Grafton–Keokuk.	Keokuk–Fulton.*	Fulton–Chicago.	Grafton–Chicago.	Gibraltar–Port Huron.	St. Lawrence River.	Lake St. Clair.
Length of line, in kilometers	241.6	272	272	785.6	117.6	197.2	41
Number of days in the field	94	81	98	273	85	135	27
Number of days worked	73	58	67	198	71	105.5	22
Average run per day in field, in kilometers	2.56	3.36	2.72	2.88	3.70	3.21	3.63
Average run per day worked, in kilometers	3.36	4.64*	4.00	4.00	4.06	4.11	4.46
Allowable limit of closure, in millimeters	$5\sqrt{L}$	$5\sqrt{L}$	$5\sqrt{L}$	$5\sqrt{L}$	$3\sqrt{\frac{L}{2}}$	$3\sqrt{L}$	$3\sqrt{\frac{L}{2}}$
Probable error, in millimeters per kilometer	±0.74	±0.67	±0.84	.....	±0.48	±0.61 ±0.48	±0.33
Observers	J. B. J. and O. W. F.	J. B. J. and O. W. F.	J. B. J. and O. W. F.	J.B.J. and O. W. F.	O.W.F.	D. M.	D. M.

* A hand car was used on this work, thus facilitating progress.

The figures in Tables Nos. 33 and 34 show that duplicate readings do not materially affect the cost or progress of the work, but that the differences which may exist must be explained by the many other factors mentioned. The writer feels safe in asserting that he can duplicate the speed of any of the examples cited in the discussion when working under the same conditions and specifications.

The reasons given by Mr. Wilson,* which required the "best effort" "to state the facts as nearly as they could be derived from published reports," were sufficient to cause the writer to dispense with further data on the above subject. In most cases it is doubtful

* *Transactions*, Am. Soc. C. E., Vol. xxxix, p. 376.

Mr. Molitor. whether the cost implies single or double lines, or whether the salaries of observers are included. Mr. Wilson's paper was not overlooked.

The writer will now attempt to answer as briefly as possible the questions brought out by the discussion and which have not already been covered in a general way by the foregoing.

To remarks by Mr. Horace M. Marshall, the writer would reply that precise leveling is not as new in this country as he intimates, in fact, when it was taken up by the United States Lake Survey, in 1875, not very much had been done in European countries. The best work has since been done in this country, and the method still generally used in Europe is that by bubble readings, recently discarded by the Coast and Geodetic Survey.

Mr. Marshall has overlooked the fact that the errors which the writer attempts most to eliminate by double pairs of sights are those due to refraction, temperature and pointing, and these can only be eliminated by repetition of observations. In discussing Mr. Wilson's paper, Mr. Marshall * favors re-reading the back sight after each fore sight and taking the mean to give a reading simultaneous with the latter. But what guarantee has he that the fore sight does not change, and would this not give the back sights double weight?

This point and a number of others depend merely on a definition of terms. What satisfies Mr. Marshall's specifications is not necessarily called precise leveling by the writer.

In common with others, Mr. Marshall imagines many difficulties arising from the use of 2-mm. rod graduations. They can certainly do no harm, even for his class of work, because the centimeter graduations are present in practically the same form as on the Kern rods. The 2-mm. graduations materially increase the accuracy of work with less strain on the observer, a fact which can best be ascertained by practice, but never by inference.

No readings are supposed to be taken on the 2-cm. triangular figures, as Mr. Hayford supposes, these serve merely to facilitate counting, and replace the numerals commonly used.

There is nothing curious about finding the work of the Vicksburg Engineer Office omitted from Table No. 21, when the data are not obtainable in proper detail.

The data furnished in Table No. 26 show what a person can do for himself when he wishes to attribute "foolishness" to others. Although the writer does not consider the application of least squares to leveling as free from criticism (page 889), it is not very sensible to compare errors of closure of loops, expressed in millimeters per kilometer, with the probable error of a pair of lines, as Mr. Marshall has done (page 1105†). Had he computed the probable error of his lines he would

* *Transactions*, Am. Soc. C. E., Vol. xxxix, p. 400.

† *Proceedings*, November, 1900.

not have made such an elaborate display, which is evidenced by the result, ± 1.1 mm. per kilometer found by Mr. A. E. Kastl for the stretch Grand Bend—Smithland of the Red River levels. Mr. Molitor.

In reply to Mr. Wilson it may be said that the paper will probably not "befog" the careful reader in the conclusions which he is to draw from the voluminous theoretical discussion. On the contrary, had this been omitted, the paper would have been decidedly wanting in substantial proofs of the methods advocated.

Regarding the comparative value of self-reading and target rods, Mr. Wilson stands alone in his favoritism of the latter. In all probability, the thread interval, in the instrument used, was altogether too large to admit of proper results on self-reading rods.

The criticism offered against the steel turning point pin is unfounded, and no trouble was ever experienced in keeping the sockets clean, even when working over roads which were impassable by vehicles on account of mud.

No recommendation was made regarding the concealment of benchmarks, and both exposed and concealed marks were used by the writer.

The fear expressed by Mr. Wilson "that the imposing array of mathematical formulas," etc., ... "will deter civil engineers . . . . from attempting work of this class" is not exactly flattering to the ability of engineers to read understandingly; for, besides demonstrating the complexity of the subject, the writer has very clearly shown and illustrated its simplicity in practice.

The information given by Mr. E. G. Fischer respecting the material used in the new Coast and Geodetic Survey leveling instruments is highly interesting and valuable, and on these lines the Buff and Berger Precise Level No. 2 768 might be considerably improved. However, the criticisms relating to the design of this level are not all correct.

The agate points referred to did not wear the collars by any measurable amount during a whole season's work, but, for fear of such an effect, the writer had them replaced by soft brass points. The change could not be regarded as any improvement, so far as was noticeable.

Mr. Fischer's interpretation of the writer's motive in having the wye contacts in different planes from the respective level tube contacts on the steel collars is altogether wrong. This recommendation was made to prevent any deleterious effect on the level tube contacts as a result of worn collars, or, in other words, the relation between the axis of collimation (as defined by the centers of the collars) and the level tube would remain unchanged, no matter how much the collars were worn on the wye contacts.

With a little field experience Mr. Fischer would see the advantage of this, and would understand why the striding level can be relied on

Mr. Molitor. for indicating the direction of the line of sight to a much greater extent than can reasonably be expected for a fixed level tube. The cork or blotting paper for mounting the level vial is not objectionable in practice, though, in principle, the elastic metallic supports appear to be better.

Mr. John F. Hayford has contributed a very lengthy discussion, and, while he has given the subject a great deal of consideration and study, he views things almost entirely from a theoretical standpoint. It is not surprising, therefore, that he should dissent from many of the conclusions arrived at by the writer through practice of a most painstaking nature.

Mr. Hayford deserves credit for having pointed out numerous errors in faulty diction and in some of the theoretical reasoning, though, in several instances, he incorrectly builds up arguments on such errors, and attempts to disprove facts.

In regard to the 1900 Coast and Geodetic Survey Level and the high tribute paid thereto by Mr. O. W. Ferguson, who has always worked with Kern levels previous to 1899, and has never used a Mendenhall level, and probably not even seen one, the writer questions the right to apply to the Buff and Berger Precise Level No. 2768 the arguments holding good for a comparison made between the Kern level and the 1900 Coast and Geodetic Survey instrument. The writer has used both the Mendenhall and Kern levels, and can say with authority that the disadvantages cited in opposition to the Kern level do not in any way apply to the former, for which reason (as stated in the paper) the Buff and Berger Precise Level No. 2768, or the Mendenhall level, was chosen in preference to all other levels described. There could be no reason, other than true merit, for favoring this instrument now, because the firm Buff and Berger is out of existence, and, so far as known, this style of instrument is not offered for sale at the present time.

All the objections advanced by Mr. Ferguson against the Kern level are due to slight defects in design which have all been remedied in the Buff and Berger Level No. 2768, even to the extent of producing a mirror which shows merely the level-tube graduation without surrounding trees and houses.

The Kern level tube is held in position by clamps, and cannot be readily reversed or removed. The writer's programme of reading, therefore, is not well adapted to this instrument.

Besides leveling up, nothing farther is necessary to put the Buff and Berger instrument in shape for observing, neither does it require any labor to prepare it for carrying. The level tube is not held, but rests freely on the telescope collars, and is guided laterally by guides of the wye frame. The observer always carries the level tube and the umbrella, and the umbrellaman carries the bare instrument and tripod.

Mr. Molitor.

In the general directions for the observers of the Coast and Geodetic Survey, it is required that, whenever a pair of lines fails to close within the prescribed limit, both lines must be re-run. If a third line should happen to form an acceptable pair (direct and reverse) with one of the first lines, why would these not be as good as a third and fourth line. The first pair of lines must have been run at different times (or else be simultaneous, which is not permissible), and there is no reason why the errors of one should reflect on the quality of the other. It is the writer's experience that the errors nearly always belong to one line (see Table No. 37), and the experienced observer can generally identify the poor one by examination of the notes and weather remarks.

Reading the rods to the nearest millimeter will be found entirely inadequate for high-class work, especially for sights shorter than 50 m.

Section 6 of the regulations covers the idea carried out by the writer in duplicating readings in reverse order, so far as this is possible with single sights.

Mr. Hayford favors continuing the work throughout the day. However, the kind of work which the writer has done permitted this only during cloudy weather and during the spring and fall months, but not during the warm summer months. There may be different conditions in other parts of the country which would alter this circumstance, but, so far as known, this obstacle has been encountered whenever high-grade work was attempted. Most of the work done under the Mississippi River Commission during the summer was run early and late in the day. This point is clearly covered on page 861, and careful reading will not admit of much difference of opinion.

The importance which the writer places on the careful equalization of sights is seen on pages 863 and 867 (level notes), though this is done as an additional safeguard, and no absolute reliance attaches to this feature for the elimination of errors.

The resemblance between the writer's and the old Coast and Geodetic Survey method is not so striking when it is remembered that the latter method is based on bubble readings which are afterward reduced to the horizontal, while the former necessitates horizontal sights with the bubble always in the center.

It is difficult to understand wherein the writer's method and the Buff and Berger Precise Level No. 2768, seem to leave the way open to systematic temperature errors when Mr. Hayford freely admits that such errors are not manifested by work under the Corps of Engineers with the Kern level, which is designed on the same lines as the former instrument. This statement is entirely illogical. If Mr. Hayford's assumption is correct, why, then, is not the work done with Kern levels subject to these errors? The principal changes made by the Coast and Geodetic Survey in 1898, were in the methods of observing and not in

Mr. Molitor. the instrument. Why, then, credit the improvement in results to the instrument alone and not to the new method?

Mr. Hayford advances an explanation for the cause of systematic temperature errors which were inherent in the old Coast and Geodetic Survey levels. He then claims that the work of 1899, done with the intermediate type of level (with striding level, etc.), and that done under the Corps of Engineers, with the Kern level, was in each case free from systematic error, and then expresses the belief that the writer's levels, run with the Buff and Berger level of similar design to these two, are subject to such error. If the intermediate level was free from systematic error, why did he discard the striding level, and design the 1900 instrument? Also, why does he cast reflection on the validity of the writer's experiments given in Table No. 6, when the results there given confirm his own theory?

In attempting to discredit the observations in Table No. 6, Mr. Hayford attributes the observed changes in the difference of elevation between Points 1 and 2 to the method of observing and errors of reading.

The method of observing cannot be responsible for the variety of results there given, because the readings were not subject to sudden and erratic changes, and ten sets could be taken in quick succession without obtaining greater differences than 0.2 mm. The readings changed only when the atmospheric conditions changed. All this is contradictory to the view so liberally expressed, that the time required to take a set of readings affects the results. This is true for the time interval elapsing between a back and a fore sight, because of possible refractive changes, but it is not true for a duplication of pairs of sights. The mean of two pairs will always be better than either one by itself.

The range of differences in the readings in Table No. 6 is between 1 and 2 mm. for a 30-m. sight read on a 2-mm. rod graduation, where, for 50 diameters magnification the apparent magnitude of the graduation is about one-half natural size. If Mr. Hayford can afford to call such differences errors of reading, he might as well designate precise leveling as nonsense. The same applies to the readings in Table No. 9, where the observed differences are still larger.

Mr. Hayford makes several partial or contradictory statements regarding small errors, some of which he calls negligible and others equally small which he takes particular pains to emphasize.

In speaking of the non-importance of changes in height of instrument resulting from re-leveling, when the wye cradle is pivoted at one end, he says that this might amount to $\frac{1}{10}$ mm. per station for the 1900 Coast and Geodetic Survey level, and that this is a negligible quantity. For a coarser level it might be several times this amount, but assuming the small quantity as representative and that the back sights are always read first, then for 50-m. shots this would produce a

systematic error of 0.14 mm. per kilometer, and for 20-m. shots the amount would be 0.36 mm. per kilometer. Mr. Molitor.

Also, in discussing the effect of heaving or settling of the instrument or rods he claims that such errors seldom exceeded 0.25 mm. per kilometer and were generally less than 0.1 mm. He also figures that this would amount to an average movement of from 0.007 mm. to 0.04 mm. per station, and concedes that either quantity is too small to be readable. In another place it is required to read the rod only to the nearest millimeter on a 1-cm. graduation. In this instance, however, Mr. Hayford is not satisfied with his conclusion, for he then asks: "Is it not true that this source of error is sufficiently dangerous to make it imperative that all lines should be run in both.... directions.... if the highest degree of accuracy is desired?"

The writer nowhere asserts that settlements of this magnitude are impossible, but he states that these would be quite immaterial to work where readings are taken only to the nearest millimeter, and adds here that he would not run direct and reverse lines for the purpose of eliminating such errors, were there not many other much more serious errors to be considered.

However, if duplicate lines are justifiable for the sake of eliminating such a minute and doubtful quantity, why, then, should it be permissible to pivot the wye cradle at the end, where the error is equally large and probably several times larger?

In giving Table No. 3, no assertion was made respecting the conclusiveness of the evidence presented; in fact, the subject is treated with considerable reserve, and the reader is allowed to draw his own conclusion.

Mr. Hayford, in citing the excellent qualities of the 1900 Coast and Geodetic Survey level for holding adjustments, concludes that a lack of such qualities in the Buff and Berger level prompted the writer to state that no reliance should be placed on the capability of a level tube for holding its adjustment.

While it is not disputed that in point of material the latter instrument might be much improved, and such improvement was advocated by the writer in 1898, by proposing the substitution of a wooden or glass tube for the bronze case of the level tube, yet, with the instrument as it is, no difficulty was ordinarily experienced in keeping the level in almost perfect adjustment, as is shown by the readings (see Tables Nos. 12 and 13), where the combined bubble and collimation error is measured for every sight. Also, to cite extreme tests, this instrument was last used in 1898 at a temperature of about + 50° Fahr., and was in good adjustment. It was then put into the box, transported 4 miles by wagon and 60 miles by rail; it then stood in a warm room for several days, and, finally, was transported in a farmer's wagon (without springs) for a distance of 36 miles over a rough frozen

Mr. Molitor. road and used to run a duplicate line of 1 km. at + 10° Fahr., all without adjustment.

There were many cases, however, when the bubble was adjusted several times during a single day, but this was done merely to keep the error within small limits.

Collimation was adjusted only twice during a whole season, and when it changed it did so suddenly.

Still, with these comparative facts in plain sight, the writer would not dispense with the striding level or the invertible telescope, for the very evident reason that, without these, there is no absolute assurance of the condition of the instrument except at the times when the errors are measured. Besides, a careful determination of the instrument errors is quite time-consuming and frequently unsatisfactory, for which reason such determinations were entirely abandoned by the writer in his field methods.

The 1900 Coast and Geodetic Survey level is, in principle, not superior to a dumpy level, in fact, it is so simple that it ceases to possess the virtues of a precise level. In saying this, the writer does not mean that good work cannot be done with such an instrument, but that it is difficult to determine its errors of adjustment, and a great deal must be taken for granted, which the results of careful work have taught the observer to regard with suspicion.

In this new instrument the thread error cannot be measured accurately, and the thread adjustment should not be changed in the field. Also, the level-tube error is not directly measurable, and the resultant error of the instrument must be determined by the so-called peg adjustment, which is perfect in theory, but very inaccurate in practice, unless the mean of many observations (say, 10 to 20) be used. This instrument error is measured only once daily, and absolute reliance is placed on the constancy of such error throughout the day. Were this combined bubble and collimation error observed continuously, as is done by the writer's method, it would be found to undergo periodic changes, a fact which passes unobserved by the Coast and Geodetic Survey instrument and method.

If the levels run by the Kern instrument are free from systematic cumulative errors, as is freely admitted, even though this instrument has a striding level and invertible telescope, why, then, was it necessary to avoid these advantageous features in designing the 1900 level, and add others which are distinctly undesirable? Would it not have been proper to first establish the fact that the cumulative errors found in the old Coast and Geodetic Survey levels were due to defective instruments, and not to faulty methods of observing? It might be interesting for Mr. Hayford to run a stretch of levels, both by the old and new methods, to determine this fact.

While the least probable error of any work by the Coast and Geo-

detic Survey in 1899 is ± 0.65 mm. per kilometer, showing a marked improvement over the former work by this department, yet such a value is among the high ones for work with the Kern level, and would scarcely be comparable with the writer's best work, where the probable error was ± 0.33 mm. per kilometer. Mr. Molitor.

The writer, therefore, contends that nothing has been gained by the 1900 Coast and Geodetic Survey level, that the design is a step backward, but that the mechanical execution and materials used are worthy of imitation and may be accepted as a decided improvement over anything yet produced.

The erroneous statement, page 795, relative to the coefficient of expansion of paraffined rods was inadvertently committed and has been righted.

Regarding the question of foot-plates, the writer would add that he has used both plates and pins, and could under no circumstances give preference to the former. The only case where the pin cannot be used is on bed rock, and here the plate is quite as useless, and the rods are generally held on small knobs cut with a cold chisel. The writer has worked over all possible kinds of country, and has never found a case where the pin did not give the highest satisfaction. Like experience is shared by others. This again does not mean that good work cannot be done with foot-plates, but it is intended to convey the idea that the pin is safer and less likely to be disturbed, and, consequently, saves re-running of work. The use of the pin is regarded as a step in advance, but nobody is compelled to adopt it on this account.

Mr. Hayford fails to see the advantage of placing the zero of the rod graduation above the foot of the rod. No advantage is claimed, but it is good practice, because the end of the rod is subject to wear and does not afford a good point for making comparative rod measurements.

It was not the writer's intention to involve "several generations of astronomers" and others in confusion over the subject of collar inequality. So far as precise levelers are concerned, the writer believes he has discovered a disparity between the theoretical solution of this problem and its practical application. As to the astronomers, it may be added that a discussion bearing on this point has been published by Dr. W. Jordan.*

The writer is indebted to Mr. Hayford for pointing out some very glaring errors on pages 830 and 831, some of which have been corrected by explanatory foot-notes. However, imperfect as this reasoning may be, the fact still remains that the common method of measuring the error due to collar inequality does not give the true inclination between the axis of collimation (as defined by the centers of the collars) and the axis of the level tube, except under certain conditions.

* "Grundzuege der Astronom. Zeit und Ortsbestimmung," Berlin, 1885, p. 46.

Mr. Molitor. Mr. Hayford states that when corrections for curvature and refraction are applied, "the method shown in Table No. 9 seems to be correct, and should give a value of the collar inequality in agreement with that of the ordinary method * * * except for unavoidable errors of observation." He then quotes the various values found for this function at different times by the two methods, and concludes that "the great range of these values, and the fact that they are unusually large, is an indication that the concentration of the wear on the telescope collars at the four small areas has produced the effect which should be expected."

In the absence of further proof, such a conclusion is wholly unwarranted, and displays a very unscientific way of disposing of the subject. As a matter of fact, the collars show no appreciable wear, which is visible or measurable by either of the methods named, both before and after the instrument was used for over 100 miles of levels by the writer, and following the method of double sights with level tube reversals. This, Mr. Hayford might have seen by inspection of the values which he quoted and which are repeated in Table No. 35 with dates of observation.

TABLE No. 35.

Date.	ε by Common Method.	ε by Writer's Method.	
		As observed.	Corrected for curv.
	Millimeters per meter.	Millimeters per meter.	Millimeters per meter.
Aug. 11th, 1898....	+0.0235	+0.0635	+0.0555
May 5th, 1899.....	+0.0276	+0.0624	+0.0544

Hence, whether, or not, the writer has succeeded in theoretically demonstrating the reasons for this disparity, the fact still remains that the two methods do not give similar results. For different instruments these values would, of course, bear a different relation to each other. The close agreement of the values found on August 11th, 1898, with those found on May 5th, 1899, after running 100 miles of levels, shows the minute wear which took place on the collars.

According to Mr. Hayford, the collars might have any regular shape without affecting the validity of the common method, so long as the angles α and β [Figs. 15 (a) and 15 (b)] are equal.

While this is all true for a theoretically perfect reversal of the telescope collars in the wyes, yet, in fact, such reversals would not be possible, except for circular collars, for which reason the assumptions on page 830 are cited.

Mr. Molitor

The function sought is the angle ε between the axis of collimation through the centers of the collars and the level tube axis. Supposing, then, that the collars were elliptical, how, in practice, would the common method determine this angle? Also, if the contact points between a collar, the level tube and the wye support are not in a plane, how can the theory apply to collars which have become worn from use?

Referring again to Figs. 15 (a) and 15 (b), and calling all dimensions linear distances for collars 1 m. apart, in which case ε, p, x, y, t, q, w and w' could also represent tangents of angles, in millimeters per meter. Then $p = R - r$ and

$$t = p \cos. \frac{\beta}{2} \cot. \frac{\beta}{2}, \; w = \frac{p}{\sin. \frac{\beta}{2}} = \frac{t}{\cos.^2 \frac{\beta}{2}} = p \sin. \frac{\beta}{2} + t,$$

$$\text{and } y = w - p.$$

Also,

$$q = p \cos. \frac{\alpha}{2} \cot. \frac{\alpha}{2}, \; w' = \frac{p}{\sin. \frac{\alpha}{2}} = \frac{q}{\cos.^2 \frac{\alpha}{2}} \text{ and } x = w' - p.$$

By assigning values to α and β, and assuming $p = 0.0276$ mm., the other functions may be found as indicated in Table No. 36.

TABLE No. 36.

$\alpha = \beta = 180°$.	$\alpha = \beta = 0$.	$\alpha = \beta = 20°$.	$\alpha = \beta = 90°$.	$\alpha = 180°$ and $\beta = 90°$.
Mm.	Mm.	Mm.	Mm.	Mm.
$w = w' = 0.0276$.....	Infinite.	0.1596	0.0390	$w = 0.0390$ $w' = 0.0276$
$t = q = 0.0000$.....	"	0.1543	0.0195	$t = 0.0195$ $q = 0.0000$
$x = y = 0.0000$.....	"	0.1320	0.0114	$y = 0.0114$ $x = 0.0000$

These figures illustrate very strikingly the effect which changes in α and β have on the telescope pointing when the level tube is always horizontal.

The total angle measured by the level tube in performing the ordinary determination of collar inequality is $4\varepsilon = 4p + 2x + 2y$, and the angle between the collimation axis and the level tube axis is $\varepsilon = p + x$, which is one-fourth of the total angle only when $x = y$.

Hence, when α and β are unequal, then x and y are unequal, and $\varepsilon = p + x$ cannot equal $\frac{1}{4}(4p + 2x + 2y)$, which would be one source of error, though small in comparison to the discrepancy found. However, the foregoing may serve to point out the chances for errors resulting from irregular collars and the other factors mentioned on page 830.

To avoid any doubt regarding the interpretation of the common

Mr. Molitor. method, one set of the observations made May 5th, 1899, with Buff and Berger Level No. 2768 is given here in full:

Telescope.	Level tube.	Bubble readings from center.			
Eye end N.	Direct.	N. end.	17.0	S. end.	16.4
" " "	Reversed.	" "	16.9	" "	16.4
			33.9 (+ 1.1)		32.8
			+ 0.275		
" " S.	Direct.	" "	13.1	" "	20.2
" " "	Reversed.	" "	13.5	" "	19.9
			26.6 (— 13.5)		40.1
			— 3.375		

Mean N. end reading minus mean S. end reading $= 4\epsilon = +0.275 - (-3.375) = +3.650$
or $\epsilon = +0.912$ bubble division.
The value of the level tube was 6.51 seconds, which gives $\epsilon = 5.937$ seconds, $= 0.02884$ mm. per meter.

The method here followed is taken from "Theory and Practice of Surveying."* See, also, example on page 830 of the paper.

The conclusion to be drawn from this rather lengthy discussion is that, so far as the subject of leveling is concerned, the better and probably more accurate method to follow in the determination of the residual error resulting from collar inequality and possibly other sources is the one given by the writer in Table No. 9; except that a smaller excess of sights (say from 20 to 30 m. instead of 70 m.) might be chosen, to reduce the error of refraction and curvature to a minimum, though correction for this should be made in every case.

The criticisms of Table No. 16 are not proper, and the final figures in Table No. 31 are entirely unjustifiable, because the value 0.0635 includes curvature and refraction for 70 m., and the value 0.0276 is shown to be erroneous, although correctly determined by the common method for finding the error due to collar inequality.

It is admitted that the data presented in Table No. 6 are not entirely conclusive, a fact well known to the writer before publishing them. However, the conclusions stated on pages 844 and 886 were arrived at prior to making the set of experiments given in Table No. 6, by observing the closures on lines run during June, 1899, and the special experiments were really made to give more weight to these conclusions.

The writer had intended to make a much more elaborate set of experiments, by observing on a set of 8 points around the horizon (all equidistant from the instrument), for a variety of weather conditions and different methods of shading the instrument. This fond hope was never materialized, owing to the fact that suitable conditions did not present themselves during continuance of the work, and after comple-

* By Professor J. B. Johnson, page 574.

tion of the line (Lake St. Clair levels) the party was disbanded, and no permission to indulge in farther investigations of this kind was obtainable during the writer's connection with the service. It is confidently hoped that such work may still be undertaken, and much valuable information may be expected therefrom. Mr. Molitor.

However, as to the validity of the conclusions cited, Mr. Hayford's attacks are not altogether warranted, even in the absence of other supporting evidence. For, if the facts here supposed to be proven are erroneous, then the systematic temperature error found to exist in the older Coast and Geodetic Survey levels is likewise unsupported, for both show apparently the same thing, viz., both "tend to make elevations carried toward the sun too great, and *vice versa*." Why, then, should Mr. Hayford reject these experiments which show this, and accept merely his theoretical proof?

Again, if Mr. Hayford objects to basing such "important conclusions" on changes as small as 0.9 mm. on a 30-m. sight, how is he warranted in drawing any conclusions from errors amounting to only 0.25 mm. per kilometer, as he has done; and what would he designate as a measurable error? He also attempts to destroy the weight of the observations in Table No. 6, by pointing out a change in the thread interval, which would naturally occur on such a set of readings.

Each thread taken by itself will constitute a line of levels wherein the collimation is not in adjustment, except possibly for the middle thread. An examination of the table gives differences of elevation for thread 1, varying by 1.0 mm. between maximum and minimum values. Likewise, the middle thread 2 gives 1.3 mm. and thread 3 gives 2.8 mm. The average of these is 1.7 mm. The range for the mean values given in the table is 1.2 mm., after correcting the first value, erroneously given in the *Proceedings* as 287.9 to 288.3 mm. Hence, while the thread distances did undergo changes, the mean values give a range, 1.2 mm., almost identical with that of the mean thread, 1.3 mm., when taken by itself. Therefore, the conclusions which the writer has based on the observations as a whole are not vitiated by the variations in thread distance.

Mr. Hayford further states "that there is no evidence put forward * * * to determine which of the many differences of elevation was the true one." While this was not discussed at length, it hardly seems probable that anyone would exercise such poor judgment as to assume that the mean of all the values is the best, when there are such apparent evidences of disturbances as those recorded in the remarks column and shown by other comments in the text. The first pair of sights together with the last five pairs might readily be accepted, as indicated by the readings, their mean values and the remarks. This mean is 287.93 mm. The other values, however, indicate decidedly the presence of disturbances, and there is every reason to reject them.

Mr. Molitor. The indications are that the direct rays from the sun constitute the disturbing element. Hence the claim, that the true readings are those taken in the absence of this disturbance (as before sunrise or under dense clouds), is correct within knowable limits. This must be acknowledged, if any true readings are considered possible, and it was taken for granted that this fact was shown directly by the observations without further proof.

Another fact, not so clearly shown by the observations, but substantiated by many of the writer's lines, is that the temperature error manifests itself only during midday hours, and on most cool days (as in spring and fall) it is entirely absent. This is probably not a new discovery, for nearly all the high-class work done under the Mississippi River Commission, mostly by Assistant Engineers J. B. Johnson and O. W. Ferguson (see Table No. 21), was done early and late in the day, and this is the work so generally recognized as free from cumulative errors. Hence, the practice of the Coast and Geodetic Survey to continue work throughout the day, together with the older method of reading the level tube off center and reducing to the horizontal, may be accepted as very conclusive evidence of the causes for cumulative errors in the old work.

The writer's conclusions on page 844 are in every way verified by experience and supported by the observations in Table No. 6, as explained on page 843. Mr. Hayford's statement to the contrary, "that direct and reverse lines run during the same half of the day would close well," is covered by Conclusions 1 and 2, on page 844, where the time interval between the runnings is either zero, as for simultaneous work in two directions, or the interval is too short to allow the conditions to change. Usually, this is not the case when both lines are run by one party.

A careful reading of page 843 will leave little chance for doubt as to the validity of the writer's conclusions in this respect, though a few examples of lines showing the practical results are given in Table No. 37, in order to strengthen these arguments.

These stretches are not particularly selected, but represent all those of wide closures where constant errors might be expected. The following facts are striking:

1.—The rejected or bad line of a set is invariably the one where the shortest sights were taken, a condition made compulsory by difficult reading. Ordinarily the shortest sights would give the most accurate results.

2.—All the rejected lines are those run nearest to noon, where the temperature effect is greatest. This fact enabled the observer to identify the bad line of each pair, so that a third line would always supply the data for an acceptable pair.

3.—There is a marked tendency for lines to close well when run

TABLE No. 37.—Lake St. Clair Levels, June, 1899.

B. M.	Determined from:	Distance.	Direction.	Difference of elevation.	Resid. from mean.	Length of shot.	Excess of F. S.		Time of Day.				Weather.		Magnetic bearing.	Closing error.
							Dir.	Rev.	Dir.		Rev.		Dir.	Rev.		
									From	To	From	To				
		m.		mm.	mm.	m.	m.	m.								mm.
			D	— 29.69	—0.95	40	+0.14	.....	8 A.	9 A.	.....	.....	clear.	.....	.....	....
			R_1	— 34.39*	.....	31.4	.....	—0.24	.....	.....	10 A.	12 M.	.....	clear.	N.	4.70
106	105	881	R_2	— 31.60	+0.95	40	.....	+0.02	.....	.....	3 P.	4 P.	.....	clear.	.....	1.91
			M	— 30.64	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	...
			D	+ 203.40	+0.26	63	+0.02	.....	6 A.	8 A.	.....	.....	clear.	.....	.....	....
			R_1	+ 210.8*	.....	43	.....	—0.02	.....	.....	3 P.	6 P.	.....	hot.	N. 35° E.	7.40
110	109	1 634	R_2	+ 203.92	—0.26	45.4	.....	—0.28	.....	.....	7 A.	10 A.	.....	clear.	.....	0.52
			M	+ 203.66	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	....
			D	— 178.19	+0.25	55	+0.16	.....	5 P.	7 P.	.....	.....	clear.	.....	.....	....
			R_1	— 172.04*	.....	40	.....	—0.88	.....	.....	8 A.	11 A.	.....	clear.	N. 35° E.	6.15
P. 40	112	1 429	R_2	— 177.70	—0.25	51	.....	+0.06	.....	.....	6 P.	8 P.	.....	clear.	.....	0.49
			M	— 177.94	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	....
			D	+ 367.07	+0.27	45	—0.50	.....	8 A.	9 A.	.....	.....	clear.	.....	.....	....
			R_1	+ 361.93*	.....	40	.....	—0.46	.....	.....	9 A.	10.30 A.	.....	hot.	N.	5.14
117	116	805	R_2	+ 367.62	—0.27	50	.....	—0.38	.....	.....	3 P.	4 P.	.....	clear.	.....	0.55
			M	+ 367.34	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	....
			D	— 740.41	—0.34	54	—0.12	.....	6 P.	7 P.	.....	.....	clear.	.....	.....	....
			R_1	— 736.52*	.....	38.8	.....	+0.24	.....	.....	8 A.	10 A.	.....	hot.	N. 30° E.	3.89
122	121	1 086	R_2	— 741.10	+0.34	54	.....	+0.06	.....	.....	7 P.	5 A.	.....	clear.	.....	0.69
			M	— 740.76	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	....
			D_1	+ 280.33*	.....	52	+2.00	.....	4 P.	6 P.	.....	.....	clear.	.....	.....	4.26
124	123	1 263	D_2	+ 282.86	+0.86	52	—0.62	.....	5 A.	7 A.	.....	.....	clear.	.....	N. 30° E.	1.73
			R	+ 284.59	—0.86	57.4	.....	+0.14	.....	.....	6.30 P.	8 P.	.....	clear	.....	....
			M	+ 283.72	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	....
			D	—1190.28	+0.74	55.5	+0.32	.....	5 P.	6.30 P.	.....	.....	cloudy.	.....	.....	....
			R_1	—1187.43*	.....	49	.....	+0.44	.....	.....	4 P.	5.15 P.	.....	clear.	N. 75° E.	2.85
126	125	888	R_2	—1188.81	—0.74	55.5	.....	+0.14	.....	.....	6 A.	7 A.	.....	clear.	.....	1.47
			M	—1189.54	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....

* Rejected.

A. = A. M. P. = P. M.

Mr. Molitor. during symmetrical portions of the day with respect to noon. Six out of seven stretches show this.

4.—Lines run during the same half of the day generally close wide. Five out of seven show this.

5.—Lines run during the same half of the day and closing well, were both run either sufficiently late or early in the day, so that the presence of deleterious temperature effects was very improbable.

All these facts substantiate the conclusions on page 844, though they do not all agree with Mr. Hayford's theory regarding the direction of the line with respect to the position of the sun. Therefore, it would seem more probable that the heat effect on the instrument resulted in a curvature of the telescope rather than in a distortion of the level tube, in which case the countersunk level vial of the 1900 Coast and Geodetic Survey level would be no advantage. The writer believes that the only superior qualities of this new instrument are due to the material used in its construction.

Mr. Hayford's remarks respecting work throughout the day, will not stand, either in theory or practice. The working hours rarely exceed 8 hours of actual instrument work, and are generally less. However, 8 hours of the day can be utilized whether the midday hours be included or not; and the amount and quality of work possible in a day when the midday hours are excluded will, with rare exceptions, exceed that producible in a day when the midday hours are included and short sights become compulsory. These midday hours may vary from 9 A. M.–4 P. M. to 11 A. M.–2 P. M., depending on the weather and season of the year.

In reality, then, there is a decided advantage in confining the working hours to those which are conducive to good results, and then working hard, rather than to "peg along" during the hottest portion of the day and afterward be compelled to reject much of the work.

The statement "that it might have been urged with considerable force that errors due to unequal temperature changes in the instrument might be expected to be smaller during the early and late hours," etc., and that "such an argument has never been put forward," is not correct for this, is one of the strong points brought out by the writer in various places, and especially on pages 842 and 843.

The question of rapidly changing refraction occurring early and late in the day is rarely ever a source of much annoyance, except during unusually warm days followed by very cool nights, However, the writer's method of observing always reveals these errors when they exist, and the celerity with which back and fore sights are taken does not permit of any great changes in refraction. Vibrations are much more annoying and dangerous. Hence, the seeming objections are not nearly as great in reality as in theory.

Mr. Molitor.

The writer does not concur in Mr. Hayford's statement that "it is true in leveling, as it is true in general, that the truth is to be reached by observing under all possible conditions." This is true when one wishes to ascertain the laws of level errors, but, these being once established, work should be done only under such conditions as are favorable to the exclusion of errors. There are numerous facts on record to prove that selected conditions are in many instances the only ones furnishing acceptable results. All base line measurements as well as most astronomical and geodetic work must be confined to special conditions

The best teacher in matters of this kind is experience, without which the theorist will often go astray.

The writer freely admits that he has made a few mis-statements relative to the theory of errors, as pointed out by Mr. Hayford. These will be rectified in the paper, except the one relative to the formula $\pm r_0 = \sqrt{\Sigma r^2}$, on page 878, where it is stated that this formula is applicable only when all stretches are of equal length. Strictly speaking, this is incorrect; but the idea intended was that the probable errors of the individual stretches were absolutely unreliable, and hence, could not serve for the derivation of other functions as r_0.

Mr. Hayford says "the computed probable error of a single kilometer is a true measure of the relative magnitude of the errors belonging to the accidental or compensating class in different lines." This error involves the probable errors of the individual stretches found from the formula $r = \pm 0.674 \sqrt{\frac{\Sigma v^2}{m(m-1)}}$, where all observations are of equal weight. When allowance is made for unequal weights the formula becomes $r = \pm 0.674 \sqrt{\frac{\Sigma (p v^2)}{\Sigma [p] (m-1)}}$.

Referring now to Table No. 19, the probable errors of the two stretches, as found from the errors of the individual turning points, are $\pm$ 0.517 mm. and $\pm$ 0.32 mm. In Table No. 18, these same stretches have probable errors of $\pm$ 0.01 mm. and $\pm$ 0.11 mm., respectively, according to the usual interpretation of the method, as applied to leveling. Would Mr. Hayford accept the closing errors of these two stretches, and determine $r_0 = \sqrt{\overline{0.01}^2 + \overline{0.11}^2} = \pm 0.110$ mm., according to the process followed in Table No. 18, or would he prefer the value $\sqrt{\overline{0.517}^2 + \overline{0.32}^2} = \pm 0.608$ mm., as would result from the probable errors in Table No. 19? Also, in the absence of the figures in Table No. 19, would he attempt to assign any weights to these observations by which acceptable values for the r's might be obtained?

In general, level observations are never of equal weight, and, frequently, both direct and reverse differences of elevation for a

Mr. Molitor. single stretch may be on the same side of the truth. Hence, by what moral right could any one discriminate between two observed values of a difference of elevation? Also, what, then, constitutes the worth of the theory of error in connection with the subject of leveling? The writer and many others fail to see any, though they may use it for want of something better.

The above stretches are fairly representative, and may safely be classed with work of the highest attainable accuracy, yet it is impossible, by any process of reasoning, to assign values for their probable errors. An outright guess would be entitled to as much weight as any theoretical value assignable.

Hence the real question, what is the probable error of a pair of lines over a given stretch, cannot be answered; from which it follows that r_0 must remain a conundrum.

The writer does not wish to convey the idea that he is opposed to or even finds fault with the theory of errors in general, but it is merely to the special case of two observations that the application of the theory is not considered of practical value.

In response to Mr. W. S. Williams the writer would say that a more careful reading of the paper would have precluded the necessity of saying more on the subject of refraction errors. The paper abounds in references to this source of error (pages 838, 839 and 861), and one of the principal reasons for the duplication of readings is to detect the presence of such errors, which single sights fail to do until a stretch is closed.

Professor C. L. Crandall has pointed out an error on page 825, in comparing the effect on rod readings by using a 2.7-second and a 9-second level tube. What the writer meant to show was the effect of a 0.1-division error, in these respective levels, on rod readings at 100 m. It would not have been fair to apply the mean error, as given in Table No. 4, to a single rod reading, where the bubble might readily be 0.1 division out of center.

Very sensitive levels have long been used by observers in Germany, Switzerland and the United States, and have given no such trouble as predicted by Messrs. Claye and Lallemand. Also the 50-diameter magnifying power of the Kern and Buff and Berger levels has not increased the weights by such enormous proportions as claimed.

In his criticism of the writer's treatment of collar inequality (pages 829 and 830), Professor Crandall is correct, to the extent that the level tube should be reversed before and after changing ends with the telescope. However, his further conclusion, that the example on page 830 simply measures twice the error of the level tube, is entirely wrong, because, in this case, the level tube was in perfect adjustment. When there is an error in the level tube, this process would measure the combined error of level and collar inequality.

Professor J. B. Johnson, though not participating in the discussion, has pointed out a few errors, mostly in Table No. 21, all of which will be corrected in the paper when reprinted in the *Transactions*. Mr. Molitor.

It was the writer's intention to present the facts relating to precise leveling, and he hereby expresses his thanks and warm appreciation to those who have contributed their knowledge, and assisted him in achieving this purpose.

With the same motive, the writer felt called upon to write a comparatively lengthy closing discussion to set aright those facts which had been assailed by seemingly plausible arguments of doubtful weight.

A very valuable collection of the results of "Precise Leveling in the United States," by Mr. John F. Hayford, Assistant, Inspector of Geodetic Work and Chief of the Computing Division of the United States Coast and Geodetic Survey, will be found in Appendix 8 of the Report of the Survey for 1898–99.

Vol. XXVII. MARCH, 1901. No. 3

AMERICAN SOCIETY OF CIVIL ENGINEERS.

INSTITUTED 1852.

PAPERS AND DISCUSSIONS.

NOTE.—This Society is not responsible, as a body, for the facts and opinions advanced in any of its publications.

THE ADJUSTMENT OF A TRANSIT SURVEY AS COMPARED WITH THAT OF A COMPASS SURVEY.

Discussion.*

By Messrs. JAMES H. FUERTES, W. H. LUSTER, Jr., and W. B. LEE.

Mr. Fuertes.

JAMES H. FUERTES, M. Am. Soc. C. E.—During the past two years, in the investigations connected with the Philadelphia Water Supply Improvement, for the Mayor's expert Water Commission, and the New York City Water Supply investigations, for the New York Merchants' Association, the speaker has conducted rapid surveys over a large area of mountainous country, for the purpose of securing data relative to stream flow and storage facilities. A short account of the methods used and the results obtained may be of interest.

For the New York investigations the work consisted of reconnaissances for aqueduct lines, and surveys of reservoir sites and water-shed limits, in the Adirondack, Catskill, Kittatinny and Shawangunk regions, for which no topographical maps were available. As the time allowed was very short, quick approximate methods were necessarily used.

In the Catskills the information desired was the location of suitable dam sites, the capacities of the reservoirs formed by these dams, and the area tributary to each, in order to arrive at conclusions as to the available daily yield of this water-shed. It was, at first, a rather disheartening task; favorable locations for masonry dams appearing only at the lowest sites on each of the three main streams, the Esopus,

*Continued from February, 1901, *Proceedings*. See December, 1900, *Proceedings* for paper on this subject by C. L. Crandall, M. Am. Soc. C. E.

Catskill and Schoharie Creeks, and the country being so rough and broken that progress was necessarily slow. Mr. Fuertes.

As a foundation for the work, the best available maps were secured. These were on so small a scale as to be of little use except for the purpose of estimating water-shed areas. The equipment of a party consisted of a pocket aneroid barometer, a pocket compass, a hand-level, and a horse and buggy. Each party consisted of three persons, two for the field and one to remain at headquarters and record at short intervals the readings of the stationary barometer, noting the exact time of each reading. Readings were sometimes taken at about 3-minute intervals, when the fluctuations in pressure were rapid. The time was noted at each reading, both in the field and at headquarters. At night the readings of the stationary barometer were plotted and the proper corrections of the field readings were made. Sometimes it was necessary to compensate for lapse of time, when an area of low pressure was moving toward or away from the observers; this was done by shifting the time scale. At times the changes in the barometer would be as much as 300 to 400 ft. in a few hours, but by taking several readings at consecutive stations the effects of such variations could be eliminated. Generally, the barometric readings, after correction, could be depended upon within about 10 ft.

The field party first meandered all the roads in, and, crossing, the creek valleys, taking bearings at every change of direction, and elevations at every angle point, and at points where the slopes changed. The distances from point to point were measured by counting the revolutions of the buggy wheel. The corrections for the slip of the wheel, according as the roads were smooth or rough, frozen, icy muddy, stiff, hilly or flat, were determined each day by plotting the day's work and checking the distances by counting the rails of the railroad track between road crossings. Where possible, surveys were made in complete circuits, so that distances and directions could be checked from two independent lines. After the main lines through the valleys were completed, cross-sections were taken at various points where the topography indicated that such sections were desirable.

Elevations were checked by reading the barometer at the different stations every time points were passed where elevations had been taken on previous days. The elevations of the railroad stations were assumed as starting points for the different lines. These were taken from the time table of the Ulster & Delaware Railroad, or from the "Dictionary of Altitudes" published by the U. S. Geological Survey. At Cold Brook Station, on the Ulster & Delaware Railroad, the barometer indicated a discrepancy of about 40 ft. in the elevations, as compared with the time table elevation. Every time this station was passed the same difference of elevation was found; it was therefore

Mr. Fuertes. checked, first with a hand-level, and afterward with a wye-level, and the barometric elevation was found to be substantially correct.

Each day's work was plotted at night, the contours at 20-ft. intervals, roads, buildings, railroads, bridges, etc., being put on the sheets, which were then sent to the New York office to be worked into record shape. The sheets for the general map were plotted to a scale of about 1 mile to an inch, and the detailed maps of the creek valleys, on a scale of 500 ft. to an inch. The plotting generally checked out quite closely; closely enough to enable the probable storage capacity of the reservoirs to be estimated with a sufficient degree of accuracy. It was found that the error was generally on the side of safety; that is, the tendency was to underestimate distances rather than to overestimate them.

The total cost of the field work for the Esopus Valley, including all salaries, team hire, hotel bills and traveling expenses, was $457; the cost of making the record maps was $136; or, a total of $593 for the survey and maps complete. The territory embraced in this survey, over the whole of which contours were taken at 20-ft. intervals, covered 9 500 acres; thus, the cost of the field work was at the rate of 4.8 cents per acre, and the cost of the record maps, on a scale of 500 ft. to an inch, about 1.5 cents per acre, making the total cost 6.3 cents per acre.

The reliability of the barometers was tested most severely in making the survey of the "Drowned Lands" in the Wallkill Valley. Just south of the crossing of the Erie Railroad over the Wallkill River, the valley widens out and forms a broad plain from one to five miles in width. This plain is nearly flat, both lengthwise and transversely, and extends well down into New Jersey. It was at one time, undoubtedly, the bottom of a lake. During the winter and spring the whole valley frequently lies several feet under water. In getting elevations in this valley care was exercised to take as many barometric readings as possible on points where elevations had been taken previously. Elevations were carried down from Goshen and Middletown. After the completion of the work, comparisons were made with the Geological Survey sheets of New Jersey, and it was found that the contours carried down from the Erie Railroad crossing fitted those brought up from tide-water through New Jersey.

In the case of the erroneous elevation found at Cold Brook Station, on the Ulster & Delaware Railroad, the attention of the Railroad Company was not called to the discrepancy, because the elevation was taken from the time-table, and was not official. The valley through which the railroad runs is quite beautiful, and is much frequented by tourists and summer visitors, and one of the features of the time-table was the publication of the elevations of the railroad stations. The profile of the railroad was not secured. At the time, it was

thought that the error might have been simply an oversight in proof- reading. The elevation is given correctly, on the authority of the railroad in the "Dictionary of Altitudes." Mr. Fuertes.

W. H. Luster, Jr., Assoc. M. Am. Soc. C. E.—The speaker has done quite an amount of topographic work, with both aneroid and wye-level, and probably did some of the work near the New Jersey State line to which Mr. Fuertes refers. Mr. Luster.

Part of this topographical work was in a rough section of the Adirondacks, where the general method followed was to run lines of levels along the railroads and country highways. These levels were used as the base for all stadia and aneroid work, vertical angles being used on all stadia lines.

In taking the topography of a township the lines were first run around the tract, using transit and steel tape, the horizontal and vertical angles were read and stadia distances recorded; the latter was reduced to the horizontal and used to check the tape distance.

A township contains 36 sq. miles and measures 24 miles around the border. The closure of the horizontal work was 30 ft. and of the vertical about 6 ft.

This work was all cross-checked by running lines on the subdivisions of the township, sometimes by transit and tape and at other times with compass and stadia, according to the importance of the line. These cross-lines always crossed a line of levels, so that perfect vertical control was secured at all times. The azimuth was checked by sun observations and triangulation.

All horizontal measurements were taken between vertical rods which were driven solidly in the ground and made vertical by the use of two attached levels. Down the center of these rods there was a slot which just allowed the entrance of a projection on a plate attached to the zero end of the tape. The tape was made horizontal by the use of a hand-level, and the distance between the centers of the slots was then read and recorded.

Some of the distances taped over had slopes of 45 degrees. Taking that fact into consideration with the distance measured, 24 miles, the closure of 30 ft. was remarkably good.

It is a peculiar fact that in all the township line work which the speaker has done in the Adirondacks, he has found that with few exceptions these lines cross the summits of all the high peaks or very close to them, and in almost every instance a triangulation station can be located on the line which will give perfect view to other stations.

At these points a small signal was erected and a round of angles measured, and at a later date it was observed on from the other stations. These triangulations were made with a 20-second Buff and Berger transit. The results of these triangulations were plotted on a

Mr. Luster. projection and the lines then adjusted to these points graphically. The scale of this map was 1 in 10 000, which made the perceptible error on the map very slight.

The topography was filled in by aneroid, which, for ground of this nature, was a rapid and fairly accurate way of working. Each township was divided into lots, the lines of which were run by compass and stadia, the vertical angles being read for the vertical control. From these lines a pacing traverse was run to the interior of each lot, and aneroid readings taken at all points of topographic interest. The remaining contours were sketched in by eye. The aneroids were read at the start and finish of each traverse, and the points taken in the interior were adjusted in proportion to the elapsed time. Readings for comparison were taken at the camp during the day by the man in charge, if his other duties did not prevent; as this often happened, these readings were little used and dependence was placed on average readings taken on the same point. These aneroid heights can be depended on within 10 ft., five or six check readings were taken on a point of known elevation, which led the speaker to take the error mentioned as a maximum.

The speed of such a survey, when all hands, fifteen men, were working on the line, was about 2 miles per day.

The foregoing method differs from that carried on in New Jersey. In that State the ground is not so rough and is not heavily timbered, so that the various features of the ground can be readily seen and no useless lines need be run. For country of this nature the wye-level was used for all topography. In the few cases where the country was hilly and timbered aneroids were depended on, but were used on only very short lines.

Formulas were never used to distribute the error, as the number of stations involved would have made the task so great that the results of the work would have been greatly delayed before publication, and, in the speaker's opinion, the scale of a map, where so small as that mentioned, does not warrant such refinement.

The paper has been read carefully, and, while admitting that a method of adjustment is necessary, the one given seems to the speaker to be too cumbersome for practical use. In making an adjustment of a survey the speaker uses the following method: The lines which can be measured without any difficulty are taken as correct and the difference then remaining is proportioned to the other lines in proportion to their lengths. If the ground is open and the located corners can be seen from two or more points in the field, a base line is carefully measured, from the ends of which these corners can be seen; the angles are measured and then the sides are computed to check the measured distances. It has been the speaker's experience that by this method very little error will be found in lines easily measured, and no refinements need be used to adjust this small difference.

W. B. Lee, M. Am. Soc. C. E.—The speaker has often used Dr. Bowditch's method of adjusting a survey, probably for the lack of something better, and has fallen into the error, common to those who have applied it to a transit survey, namely, the giving of insufficient credit to the accuracy of the angle measurements. Mr. Lee.

No survey should be accepted, the original notes of which are not sufficiently accurate within their limits, which may be anywhere between those of mountain land and city lots. This condition being satisfied, no surveyor can afford to make, nor will any owner consent to pay for, an elaborate correction. Surveys are made for the purpose of locating fixed points or corners. If the bearings and distances when re-run will not locate these points accurately, it matters not whether the error be one of bearing or distance.

Since the present practice tends to an accuracy of instrument work greater than that of chaining, the speaker would recommend that these two be adjusted to a common basis before a survey is made. Then Dr. Bowditch's simple and rapid method of correction may be applied without detriment to either.

Much depends upon the circumstances attending the making of a survey; that is, the conditions under which it is made, and the nature of the territory. Here arise abundant opportunities for the exercise of judgment.

The speaker recently made a survey of an industrial plant which was scattered along a railway for about half a mile, making a circuit then, of about a mile. The line along the railway was assumed as a meridian and its length as correct; then the meandering line behind the plant was adjusted to it. Numerous shots and measurements to corners of buildings and other fixed points proved the accuracy of the work and the rationality of the adjustment.

Vol. XXVII. MARCH, 1901. No. 3.

AMERICAN SOCIETY OF CIVIL ENGINEERS.

INSTITUTED 1852.

PAPERS AND DISCUSSIONS.

NOTE.—This Society is not responsible, as a body, for the facts and opinions advanced in any of its publications.

THE CONSTRUCTION OF GRAVITY SAND FILTERS AT NYACK, N. Y.

Discussion.*

By Messrs. JAMES S. HARING, JAMES H. FUERTES, G. KAUFMAN and MORRIS KNOWLES.

Mr. Haring.

JAMES S. HARING, M. Am. Soc. C. E. (by letter).—As outlined by the author, the origin of the change of ownership of the water-works of the village of Nyack, from a private to a municipal plant, began with the continued dissatisfaction of the consumers, in the three villages named, with the quality of the water supplied by the private company.

In 1872 Commodore William Voorhis, a large property owner in Nyack and South Nyack, constructed, principally for the supply of his own houses in the latter village, a gravity plant, taking the supply from small springs found in the hillside of these villages. Gradually the plant became enlarged by the addition of other consumers, and additional supplies were obtained from springs. In 1884, however, after much expensive and fruitless effort to obtain similar additions, it was found necessary to seek a supply by other means than that of gravity. Examinations of various other sources, including Rockland Lake and the Hackensack River, were then made, and resulted in the selection of the latter as the source of supply.

*This discussion (of the paper by G. N. Houston, Assoc. M. Am. Soc. C. E., printed in *Proceedings* for December, 1900), is printed in *Proceedings* in order that the views expressed may be brought before all members of the Society for further discussion.

Communications on this subject received prior to April 27th, 1901, will be printed in a later number of *Proceedings*, and subsequently the whole discussion will be published in *Transactions*.

Mr. Haring.

The Hackensack River originates principally from the outflow of Rockland Lake, and from a stream having its source west of New City, the latter being considered as the purer supply.

In 1895, the Village of Nyack held an election to determine upon the construction of a municipal plant. The vote was favorable, and the Board of Water Commissioners resulted. The writer was at once appointed their engineer, and designed a distribution system which was built in connection with the sewerage system, which caused its rather hasty consideration, as the pipes were laid on a shelf at the side of the sewer trench. A search was then instituted for a supply of water. Various nearby supplies were investigated, and finally a test was made by driven wells in the red sandstone, along the shore of the Hudson River in Upper Nyack, out of which many springs were flowing. These wells were in quarry sites worked many years ago, but long since abandoned. The springs from the various strata had been flowing, without any appreciable loss, for a long time, and seemed to promise results satisfactory, both as to quantity and quality. Three wells, each 8 ins. in diameter, were contracted for at a price per foot which left to the Water Commissioners much latitude as to the depth and the final number of wells to be driven. The depth of the deepest well was 285 ft. and that of the remaining two very much less, when a test was instituted, at first with the barrel pump owned and operated by the contractor, but this having a capacity of only 100 galls. per minute, the writer advised the Commissioners to apply a more thorough test, and succeeding in getting the necessary plant to pump by the use of compressed air. This test was continued without intermission for one week, the quantity pumped averaging more than 100 galls. per minute during the whole of that period. Measurements were made from time to time by which the depression of the water table, both in the well pumped, and in each of the other wells was recorded, and, previous to the constant pumping, the length of time taken by the water-table to recover its normal height was also noted. For six days the test, both as to quantity and quality, seemed to be satisfactory, but upon the seventh day, when it was proposed to end the test, a sample of water taken for analysis was found to be salt. It would be difficult to determine at what time during the test the water became salt. It is a fact that people were using the water pumped during the whole time the test was being made, and that during that time a local chemist was analyzing the water for his own information, but, until the time mentioned, there was no discovery of the fact that the water was salt. The probability is that the salt water came in very gradually as the elevation of the water-table was lowered, the latter finally reaching a point below that of the bottom of the river, the ordinary high water line of which was about 35 ft. distant from the well tested. The shore was a continuation of the red sandstone for a considerable distance

Mr. Haring. out, and was covered not by silt, as had been supposed, but by gravel and coarse sand only.

After this attempt failed, a gravity supply from Spring Valley, about 8 miles to the west, was investigated and practically decided upon. The supply came from a sparsely settled territory and from various small streams, one of which was gauged by the 10-in. meter now in use at the pumping station.

During the early operations of the Water Commissioners it was an open question as to whether or not they would take proceedings to condemn the private water company's plant. They construed the law as being adverse to any attempted negotiations for its purchase at private sale, even though an amicable adjustment could have been arranged, which was doubtful, popular sentiment in the village being adverse to such acquisition; but it was finally determined to take such action because of the immediate revenue to be derived therefrom, and also because of the franchises and distribution in the adjoining villages of Upper Nyack and South Nyack. Proceedings were begun, and a lengthy litigation before Commissioners of Appraisement ended in the acquisition of the private plant, but at a valuation so high that the available appropriation was insufficient to pay the cost of carrying out the gravity supply scheme.

During the time proceedings of condemnation were in progress, the Commissioners had paralleled the mains of the company in the village with a materially larger and more complete system.

One of the elements of the condemnation proceedings was the attempt of the Water Commissioners to prove the Hackensack River supply to be of objectionable quality. This was, in part, admitted by the company, and the attempt was met by showing that the supply could be filtered at small cost, thereby overcoming that objection. The experts for the company were John Bogart, M. Am. Soc. C. E.; W. F. Whittemore, Assoc. M. Am. Soc. C. E., and Mr. Joseph B. Rider. These engineers selected as the site of the filters, not the high-service reservoir, which was especially brought to their attention as a suggested location, but a place near the old pumping station, which was a few hundred feet southeast of the present filters. Later, when Allen Hazen, M. Am. Soc. C. E., was consulted with regard to the construction of a filter and its location, he also advised the present site, or one within a short distance of the site selected, the reasons given for such location being principally its proximity to the pumping station, the facilities for obtaining sand, and that the engineer running the pumps could regulate the filters, thereby saving the cost of additional labor in operation, the approach to the high-service reservoir being somewhat difficult and the cost of additional land at that point being also considerable. The writer calls special attention to these facts because of the criticism following the discovery of the bad bottom alluded to

in the paper, and of an attempt made to hold him and the Water Commissioners responsible for an improper location of the filters. Both acted on the advice and best judgment of the expert engineers connected with the condemnation proceedings and their own consulting engineer. Mr. Haring.

When the contract for the construction was let, the price fixed for the excavation was 29 cents per cubic yard, on the supposition by the contractors that the earth, or clay, could be excavated by the use of a centrifugal pump, as was done later by the second contractor in excavating in the curb of the pure-water well. The pump was put on, but the attempt to take out the clay in this manner was a failure; the material, to use the contractors' expression, being "too much like white lead to make it soluble."

Tests were made over both sites before either was selected, one being at the old pumping station, the other at the place chosen. A steel-pointed, 1-in. round iron rod, was used, and was both churned down and driven with a sledge to resistance. The results of these tests were reported to the Water Commissioners, and their attention called to the fact that they were not satisfactory; they were, however, all that were attempted, except the test excavations mentioned later, until the conditions described by the author occurred, after which, as stated by him, tests were made on short cross-sections to the north and west of the excavation. The results of the latter tests showed a stratification of small boulders and gravel sloping from west to east, and from south to north, the strata seeming to rise to quite near the surface of the meadow at a point about 25 ft. west of the west line of the excavation. This fact led Mr. Hering to recommend that the location of the filters be changed by placing them that distance to the west. On the lines of that suggestion the location of the pure-water well was changed, which accounts for its apparently angular position with reference to the filters. The iron rod used in testing the site came to absolute resistance repeatedly in the last test, and upon being withdrawn was frequently found to be much bent, yet, when the clay and gravel was excavated, and on account of the puddling caused by teams passing over it, the bottom of the excavation became semi-liquid, thus proving that nothing short of deep test pits could have shown exactly the character of the bottom at the depth required. Before the site was purchased, test pits were dug to such depth as was possible without pumping appliances, but they were too shallow to afford material information. The geological formations, afterward considered, were generally adverse to the selection of the site.

Complications with the contractors led the Water Commissioners to retain the original location of the filters as shown on the plans, and they were constructed on that site.

From the time bad bottom was discovered, the writer has been

Mr. Haring. under the belief that it would be difficult to prevent separation taking place in the concrete along the edges of the floor adjoining the stringers and board covering. The placing of unequal weight by careless handling of the sand in first filling, or afterward in cleaning the filters, will be found to be a dangerous element in affecting this result; or, with the semi-liquid earth forming the bottom, on which the 1-in. flooring used for the area of the filters alone rests, may accomplish this also by the wave action due to unequal loading, which was constantly in evidence during the operations of the first contractor. Its dangerous character is shown by the spring described in the paper. The first appearance of this spring was the result of a test hole. When the rod was withdrawn a stream of water spouted up some distance above the surrounding bottom, and it in time became an enlarged boiling spring. During the writer's connection with the work, which ended in May, 1898, and while the excavation was free from water, this spring continued to be active, and was only one of several evidences that an underground flow of water was sealed up by the clay bottom only a very short distance below the point reached by the excavation. It would not be surprising to find, when the filters are emptied, that cracks, admitting considerable unfiltered water, exist along these lines, and that in time they may become very troublesome.

The writer questions the advisability of the change in Mr. Hazen's plans, from a vertical wall of brick to a slope covering of concrete faced with brick. The embankment material is especially subject to upheaval by frost, the angle of slope and the reduced thickness of the concrete, while it economizes cost somewhat, seems to the writer to do so with the loss of stability.

It may be interesting to note the writer's experience in endeavoring to have brick of proper quality selected for use under the original contract. Mr. Hazen's specifications required the use "of the best quality of hard-burned brick, burned entirely through and of uniform shape and size." The contractor purchased and brought upon the ground brick of a quality which the writer refused to accept for the pumping station structure, and would not consider at all for the filters. He condemned the brick, and the matter was appealed to the Water Commissioners, and by the writer to the Consulting Engineer, Mr. Hazen, who declined to pass upon the matter as not connected with his duties. In this condition matters remained until Mr. Hering was called in. He at once sustained the writer, and the brick were rejected. The writer, believing at all times that vitrified brick with a small percentage of absorption should be used, at least for the facing of the walls exposed to the action of frost by the fluctuation of the water in the filters, insisted upon their purchase and use. This was opposed by some of the Water Commissioners, and consent to their use could not at first be obtained. The writer then personally visited

the yards manufacturing the best hard brick at Haverstraw, obtained samples of their brick and submitted them to absorption tests; but finding such proof unavailing, he sent the samples, with one of the inspectors employed on the work, to an ice plant where they were submitted to alternate freezing and thawing. These samples were then submitted to the Commissioners, and, the proof being then no longer to be disputed, the writer was ordered to purchase vitrified brick for the facing of the exposed walls, and the best obtainable hard brick for the interior of the walls. This was done, and all the brick required for the completion of the work was delivered upon the ground under the first contract. Mr. Haring.

During all the writer's operations at Nyack, the author was his assistant, and the writer desires to bear testimony to his painstaking efforts to bring a difficult problem (for he has had many obstacles to contend with, both in and out of his profession) to a successful conclusion.

James H. Fuertes, M. Am. Soc. C. E. (by letter).—The manner in which the difficulties encountered in making the excavations for these filters were overcome is interesting and instructive. The method of construction, however, was quite costly, the amount chargeable to the excavation, sheet piling, foundation piles and other earth work, being at the rate of about $30 500 per acre of filter surface, out of the total cost of $46 700 per acre for the filters complete. Mr. Fuertes.

In the fall of 1895 the writer visited the sewerage works at Newport, Isle of Wight, which were then in construction under the direction of Baldwin Latham, M. Inst. C. E. One of the works was a covered precipitation reservoir, about 70 x 83 ft. inside, divided by longitudinal walls into three basins each 22 ft. wide. The conditions were somewhat similar to those at Nyack, the soil being a slippery clay with a strong tendency to slide and cave, the ground-water level being several feet above the bottom of the reservoir.

The method there successfully adopted was to first build the side-walls, on wide footings, in sheeted trenches. After their completion the interior was excavated, the concrete bottom laid and the partition walls and posts for supporting the roof built upon it.

A description of the method used in building the dome over the filtered water reservoir at Nyack would be of much interest. A little reservoir, somewhat similar to that at Nyack, was built last summer for the Tome Institute, at Port Deposit, Md., under the writer's supervision. This reservoir was circular in plan, 16 ft. in internal diameter, and had a capacity of 5 000 galls. The side-walls and bottom of the reservoir were of Portland cement concrete 6 ins. thick, and the average thickness of the dome, which had a rise of 2 ft., was about 5 ins. Sheets of No. 10, 3-in., diamond, expanded metal were built in the walls, bottom and dome as the concrete was put in place. The dome

Mr. Fuertes. was turned on a mound of earth, built upon a platform erected inside of the reservoir, and tamped and trimmed to the proper shape. The earth mound was covered with heavy building paper before laying the concrete. When the centering was removed the dome was found to be perfect in form and smooth on the interior surface, thus justifying the methods used. The total cost was about $250.

Mr. Kaufman. Gustave Kaufman, M. Am. Soc. C. E.—The speaker desires to be enlightened as to why it was deemed necessary to locate this filter below high water, and thus require a deep excavation in swampy ground, to do which difficulties might have been expected to be encountered? Why was not the filter placed a great deal higher, and a small centrifugal pump used to deliver the river water to the filter?

In the absence of information or reason to the contrary, it would appear that placing the filter above high water would have been by far the better arrangement. A large amount of money would have been saved in the construction, and the cost of pumping would not have been affected, because the head between the filter and the village would have been reduced by the height of the filter above the ordinary stage of the river.

Mr. Knowles. Morris Knowles, Assoc. M. Am. Soc. C. E.—Mr. Kaufman's remarks about the advantage of using a centrifugal pump bring to mind an occasion of the use of such a pump for a somewhat opposite purpose, namely, that of pumping water off the surface of the filter.

The author does not state the reason for placing the filter with the water level below that in the river, but in several instances it has been done for the purpose of saving the continuous maintenance cost of pumping.

As is probably well known, the filter at Lawrence, Mass., is placed in such a manner that the river water flows to it by gravity, and, thus far in its history, there has been only one period when this has not been possible. This was during the cold weather in January, 1900, when, for some unusual cause, accompanying long continuous dry weather, like holding the water back in some of the storage reservoirs or mill ponds above, the river was so low that it was not possible to send enough water to the filter to supply the city's use.

Two centrifugal pumps (8-in. and 6-in.), were secured, hurriedly placed in position, and used for a period of about ten days, after which the water level arose, and ever since has been sufficiently high. The 6-in. pump was then returned.

At about this time it was thought advisable to test the usefulness of such pumps for removing the water from the surface of the filter, when desiring to draw down prior to scraping. When the filter is

clogged at the surface and needs cleaning, much time has been wasted, after shutting off the inlet water, and before the water has drained down into the body of the sand and the surface is dry enough to work upon. The 8-in. pump, therefore, was equipped with a double suction and discharge, together with suitable valves, so that water could be drawn from the river or from the surface of the filter and discharged to either the filter or the river, as might be desired. Mr. Knowles.

When used as an aid in draining the filter the advantage is so manifest and the saving in time so great, that the wonder is that it was not put into practice before. Thus the pump has two uses, one in case of emergency, and the other, originally secondary, but now the regular one, whenever scraping is necessary; and the investment has proven a profitable one.

AMERICAN SOCIETY OF CIVIL ENGINEERS.

INSTITUTED 1852.

PAPERS AND DISCUSSIONS.

Note.—This Society is not responsible, as a body, for the facts and opinions advanced in any of its publications.

FILTRATION OF WATER FOR PUBLIC USE.

An Informal Discussion at the Annual Convention, July 3d and 5th, 1900.*

Subject for Discussion.

"The several Processes now used for the Removal of Objectionable Matter; their Comparative Sanitary Effect, Cost and Reliability."

By Messrs. Gustav Heinke and Nicholas Simin.

Mr. Heinke. Gustav Heinke,† Esq. (by letter).—Filtration will always be of importance for public water supplies, as there will always be cases where surface water must be used and, consequently, filtration resorted to.

The chief point in a public water supply is, that healthful water be supplied.

From an ideal or scientific point of view any surface water may be suspected, but practical conditions must also be regarded. That the efficiency of sand filtration is proved seems to be beyond doubt, as the state of health of all the large towns is excellent, wherever surface water filtered through sand beds is supplied. That epidemic diseases have been originated or spread through the use of filtered surface water, has not been proved in any one case.

* The previous discussion of this subject, for which no formal paper was presented, was printed in *Transactions*, Vol. xliv, p. 399. The discussion is continued in this number of *Proceedings*, in order that the views expressed may be brought before all members of the Society for further discussion.

† Chief Engineer, Water Works Company, Brunn, Austria.

Whether sand filtration or so-called mechanical filtration is to be used may be decided in every special case. Each filter plant is a special case and has to be treated as such; how it is best operated has to be found out by practice. Mr. Heinke.

The general rules for filtration are now well known, they have been found out empirically, and are a matter of experience and practice. There have been no essential alterations made in design or operation since the time filters were first introduced for public water supply. A thicker layer of sand of uniform size could only be advantageous, but the thickness of from 2 ft. 6 ins. to 3 ft., as mostly used now, is quite sufficient—the size and quality of the sand has to be considered in determining the thickness of the layer.

For many reasons, the rate of filtration should not be too quick. The medium speed can be taken as 4½ ins. descent of water per hour, and this might safely be extended to 6 ins. without injury to the filter,

The so-called regulating chambers—the means to show how much water passes through each filter—constitute the chief feature which in recent years has been introduced into filtration. Uniformity of filtration, without quick changes, is certainly a main and important point in the filtering process.

Whether open or covered filter beds are to be used is a point which need only be governed by the climate of the locality where they are to be used. In places where strong and long-continued frosts are the rule, the writer would recommend only covered filtered beds. In covered filter beds the growth of algæ is considerably less, and, consequently, in those months when algæ are most prevalent, covered filters work, under the same conditions, for a longer period than open ones.

Bacteriology has been introduced as the latest feature in filtration. By many, the bacteriological test of the water is deemed of the utmost importance, and is supposed to give a clear insight into the working of the filters; but already there are opponents to this view, although, for some reasons, they will not come forward. Anyone having practised the bacteriological examination of water, must have come to the conclusion that there are still many deficiencies. The writer will not dispute that the bacteriological test may be used in some way as a general guide in filtration.

Can it be assumed that the microbes are so uniformly spread in a large body of water, that so very small a portion as 1 cu. cm. can be taken as an undoubted proof for the whole quantity, often millions of times larger than the portion used for the test? If one has made bacteriological tests daily for years and finds each time only a few different species, can one then come to the conclusion that a water which contains more than the prescribed number of 100 in the cubic centimeter is to be condemned, or at least suspected? Is a water con-

Mr. Heinke. taining a greater number of bacteria really injurious to health, and, contrariwise, is a water containing but a few, absolutely healthful? What is the manager of a filter plant to do if there are at any time more bacteria found in the water than allowed? Will he be any the wiser when the water is let off and the surface of the filter inspected? The writer thinks not. He may do more mischief by changing his rate of filtration, when he suddenly disconnects one or more of his filters. It is in nobody's power to control the number of bacteria passing through a filter. We may be content and happy when there are but a few in the water, but when they are in great numbers it will be at most times useless to try to find out where they came from.

In the writer's experience in bacteriological researches he has tried to discover rules, but, as soon as he thought he had established them. they were upset. Often, one finds fewer bacteria with a quicker than with a slower rate of filtration, the conditions of the filters being uniform. Even the rule that the first product of a newly charged filter contains a greater number of bacteria, does not hold good, *i. e.*, not in such a way that one might say the exception proves the rule. To operate a filter well, much depends on experience, and experience has mostly to be the teacher. If guided only by the bacteriological test one might filter with a much greater velocity than 4 ins. per hour and still have a good bacteriological result. However, in most places experience will have taught us to filter at a medium speed.

Concerning the cost of filtration, it would certainly be interesting to have it from different places, but it is useless to give it, so long as there is no agreement as to how it is to be worked out, so as to insure a certain uniformity.

Mr. Simin. Nicholas Simin, Esq.* (by letter).—Whichever system of filtration is to be used in Moscow, the problem of ozonization of water is also being studied, because this process may be used as a supplement to filtration. Although many very useful and valuable investigations have been made in America in the line of water filtration, yet a greater improvement can still be made, if good methods for the aeration of filtered water by ozonized air are elaborated and used. During a number of years scientific investigations have been made in Europe in that direction, which are giving remarkable results. The water is wholly freed from bacteria, acquires an agreeable taste, and becomes less favorable for the further growth of bacteria.

So far, a study of this problem has been made at the following places:

1. In the year 1891, at the initiative of Messrs. Siemens and Halske, investigations were made in Berlin by Dr. Ohlmueller, who demonstrated the ability of ozone to completely free the water from bacteria, and

* Chief Engineer of the Moscow Water-Works.

expressed the desire that engineers would work out appropriate devices for this method of ozonization.* Mr. Simin.

2. In the year 1895, Dr. Van Ermengem, Professor at the University of Gand, made investigations of water purification by ozone in Oudshoorn, Holland, for the Minister of Agriculture and Industries of Belgium, and also obtained good results.† Afterward, he continued his investigations, at the International Exposition of Brussels, with devices of Tindal, the same which had been used in Oudshoorn.

3. In the years 1898 and 1899, in the City of Lille, France, devices of Marmier and Abraham for the ozonization of water‡ in quantities of 35 cu. m. per hour, were placed at the city water-works, and investigations were made by a special commission. Dr. A. Calmette, a member of that commission, reported the excellent results obtained.‖ In the year 1895, these devices were shown at the Hygienic Exposition at Paris, where water was purified at the rate of 2 cu. m. per hour. The Commission at Lille recommended the ozonization of water for the entire supply of that city. At present, Dr. Calmette is experimenting at the Pasteur Institute, in Lille, France, with devices of the same kind designed for 25 cu. m. of water per hour.

4. In the year 1899, Dr. Th. Weyl made investigations at Martinikenfeld, near Berlin,§ with devices of Messrs. Siemens and Halske, for the ozonization of water, and closed his report with a statement urging that each city which is obliged to use surface water for its domestic supply, should study the question of ozonization before resolving to adopt the expensive and not fully perfected English system of water filtration.

At present, investigations are being continued at the ozonization plant of Siemens and Halske, at Martinikenfeld. River water is filtered there by a mechanical pressure filter and afterward treated by ozonized air, the analyses being made before and after the ozonization.

5. In America, an investigation on the ozonization of water was made last year at Columbia University, of New York, by Dr. George A. Soper, but the experiments appear to have been made on a very small scale.¶

The writer thinks that the great fundamental significance of this question in relation to city water supplies is demonstrated. As this process destroys all bacteria present in the water, it finally solves the task which filtration alone does not. The only subject remaining is the technical and practical side of the process, to be worked out by sanitary engineers. Up to the present time the question has been studied only by doctors, who have demonstrated the scientific importance and sig-

* *Arbeiten aus dem Kaiserlichen Gesundheitsamte*, Band VIII, p. 229, 1893.

† *Annales de l'Institut Pasteur*, Sept., 1895, p. 673.

‡ In order to ozonize water, air must be first ozonized, with which water is afterward treated.

‖ *Annales de l'Institut Pasteur*, April, 1899.

§ *Centralblatt fur Bacteriologie, Parasitenkunde und Infections-krankheiten*, 1 Abteilung, XXVI, Band No. 1, 8 Juli, 1899.

¶ *Engineering News*, Nos. 21 and 16, 1899. *Engineering Magazine*, Dec., 1899.

Mr. Simin. nificance of the process, and have given data, indicating that it is also an economical possibility to use the process on a large scale.

In addition to the investigations of the problem of filtration already made at American water-works, it would seem very important to the writer if like attention were given to the aeration of water by means of ozonized air, which could be done after the water has been filtered, and would present a complete and final solution of the purification of water from open sources destined for city water supplies.

MEMOIRS OF DECEASED MEMBERS.

NOTE.—Memoirs will be reproduced in the Volumes of *Transactions*. Any information which will amplify the records as here printed, or correct any errors, should be forwarded to the Secretary prior to the final publication.

EDWARD ARNOLD CORREA, M. Am. Soc. C. E.*

DIED JUNE 24TH, 1900.

Edward Arnold Correa, only son of Gabriel A. and Sarah Woods Correa, was born in the Island of St. Thomas, Danish West Indies, on November 7th, 1855.

His father was a gentleman of culture, with marked musical taste, and, having had the benefit of a European education and of extensive travel, was a linguist of no mean ability, speaking five or six languages fluently.

Mr. Correa's mother was of English parentage, her father having graduated at Oxford College. He was a planter, owning estates in St. Croix, Danish West Indies, which were quite valuable until the emancipation of the slaves by the Danish Government and subsequent disorder destroyed their value.

When but seven years old Mr. Correa's father died, and his mother, considerably reduced in fortune, came with her young son and daughter to the United States, locating in Brooklyn, N. Y., where the subject of this memoir attended the public schools until his fifteenth year. This was practically all the schooling he received, as his mother then removed to Iowa; but he had already earned the reputation of being a bright pupil and a voracious reader. He was employed in a bookstore at Mt. Pleasant, Iowa, for a few years, and, continuing his studious habits, improved his mind by reading the best books.

He entered the offices of the Chicago, Burlington and Quincy Railroad in 1879, without preliminary training, and, by close application and study, advanced rapidly in his chosen profession, being at all times noted for the careful, painstaking manner in which he did any work entrusted to him. He was repeatedly employed by men under whom he had served before, and his going to Mexico was due to the offer of a situation by former employers.

He remained with the Chicago, Burlington and Quincy Railroad until 1881, serving as Rodman, Topographer, etc. In 1881 he was Topographer and Leveler on the Utah and Northern Branch of the Union Pacific Railroad.

* Memoir prepared by the Secretary, from papers on file, and from information supplied by Lewis Kingman, M. Am. Soc. C. E.; J. T. Norton, M. Am. Soc. C. E., and Mrs. H. C. Jones.

In 1882 he commenced work for the Atchison, Topeka and Santa Fé Railroad Company, and, with the exception of one or two short intervals, he remained with that company until 1888. During these years he served as Leveler and Topographer on surveys, as Division Engineer on construction and as Assistant Engineer in the Building and Water-Supply Departments.

In 1889 he served as Transitman on the location, and as Division Engineer on the construction, of the Fort Worth and Rio Grande Railway, from Granville to Stephenville, Texas.

In 1890 and 1891 he became Locating Engineer and Assistant Engineer in charge of the construction of the Mexican Pacific Railroad, a proposed transcontinental line from Tonala to Frontera. During this period he also made a reconnoissance of a line from Alvarado to San Andres Tuxtla, in Vera Cruz, Mexico, and located 20 kilometers of that line.

From April to December, 1891, he was one of the Assistant Engineers on the Tampico Harbor Works, under A. F. Wrotnowski, M. Am. Soc. C. E.

During 1892 and 1893 he was Locating and Resident Engineer on the Mexican National Railroad across the Isthmus of Tehuantepec. In reference to this piece of work the following is quoted from a letter from the Chief Engineer of that road, and found among Mr. Correa's effects:

"I wish to express to you my appreciation, not only of the thoroughly conscientious work you have done for me, but also as to your ability as an Engineer. You have had charge of the location of this line from the Sarabia to the Jumuapa Rivers, which I consider by far our most difficult piece of work. Owing to the configuration of the country, Ship's Pass being the only point at which you could cross the range between these two rivers; to get a line up to it from the Sarabia, and from it to the river Jumuapa again and not carry long supported grades; to avoid rock cuts, which would not only have been nearly impossible but impracticable, from their cost, and get a line as you have, both with such good alignment and so cheap, has, I think, been the greatest engineering feat accomplished here on the Isthmus, and well shows your ability. For your prompt attention to all instructions, for your earnest manner in performing your duties, allow me to thank you. Wishing you every success in your profession, and that you may reap those rewards which you so richly deserve, I remain,

"Yours very respectfully,
"S. B. Burton, *Ch. Eng. and Gen. Manager.*
"Coatzacoalcos, February 4th, 1893."

During 1894 and 1895 Mr. Correa was engaged in private practice in Mexico, in various classes of work.

In July, 1895, he became Assistant Engineer on the Mexican Central Railroad, under Lewis Kingman, M. Am. Soc. C. E. He was engaged on reconnoissance surveys and reports of lines in various parts of

Mexico until about July, 1897. He was then engaged on location, and had charge of various pieces of construction. He then became Division Engineer at Aguas Calientes in charge of Yards and Shops plant.

Shortly after this, Mr. Correa was sent to Parral, in Chihuahua, where he was engaged in supervising the construction of a branch of the Mexican Central Railroad. He was employed upon this work at the time of his death, which occurred in camp, on June 24th, 1900, after an illness of a day or two.

Mr. Correa was elected a Member of the American Society of Civil Engineers on March 7th, 1900.

He never married, but supported his mother up to the time of her death, September 1st, 1898, and it was in fulfillment of her expressed wish that he sought membership in this Society.

Mr. Correa was a man utterly incapable of a mean or dishonest action, and, in an unostentatious way, one of the most charitable. He was a true friend, and was sincerity personified in all his dealings with his fellowmen. He was at the time of his death one of the ablest railroad engineers in Mexico. He was an indefatigable worker and was conscientious to a fault. His ideals were high, and his ambition was to do anything to which he set his hand, not as well, but better, than others could do it.

In his death the Society has lost a useful and honored member, and one who was universally respected, even by his enemies.

WILLIAM GIDDINGS CURTIS, M. Am. Soc. C. E.*

DIED JUNE 15TH, 1900.

Like many other natives of Connecticut, the subject of this memoir was of good colonial stock, tracing his lineage back hundreds of years in Essex County, England. The descendants of William Curtis, his ancestor, who came to the colonies in the ship *Lion*, in 1632, took a prominent part in the colonial life, and, when the final separation from the old country came, several of the Curtises figured in the great struggle for independence.

Mr. Curtis was born at Bridgeport, August 19th, 1849.

At the age of fifteen, he removed with his parents to San Diego Cal., thereby doubtless changing the whole trend of his life and fortunes.

At that period, there was a ready market on the Pacific Coast for probity and ability, even in the very young, and, but a year later, 1865, Mr. Curtis obtained employment with the Central Pacific Railroad Company, and began a career of success no more marked than deserved, and whose achievements only terminated with his life.

Most engineers commence the practice of their profession after a more or less complete course of study, but Mr. Curtis, beginning as a rodman at the age of sixteen, was obliged to acquire most of its theory during such leisure hours as were left him from active duties in the field and office. He passed through nearly the entire period of location and construction on the Central Pacific Railroad, an experience which profited him during his whole professional career.

He became successively Assistant Engineer, Resident Engineer, Assistant General Superintendent, and Superintendent of Track, and finally reached the position of Assistant to General Manager, and Engineer, Maintenance of Way, of the Pacific System of the Southern Pacific Company, comprising, at the time of his death, nearly 6 000 miles of railroad, which position he retained during the rest of his life.

Owing to the total lack of timber on most of their lines of railroad, the Southern Pacific Company early turned their attention to the subject of timber preservation, in which they have had marked success and have perhaps done more than any other railroad company in America, if not in the world. The achievements in this regard have rightfully been largely credited to Mr. Curtis, under whose able direction the work progressed until, at the present time, practically all the timber and ties used in or about the roadway, excepting redwood, are

* Memoir prepared by John D. Isaacs and Virgil G. Bogue, Members, Am. Soc. C. E.

treated with creosote and chloride of zinc, respectively. Mr. Curtis was an authority in this science, and one or more of his papers are among the best contributions that have appeared on this most important subject.

As Engineer, Maintenance of Way, Mr. Curtis kept himself well informed by observation, reading and discussion, and was fully abreast of the times. His enthusiasm, however, was tempered by that judgment which comes only from experience and attrition with men and the duties of life. His constant aim was to do the best possible under the conditions and circumstances presented.

His advice was frequently sought in relation to the business of other departments of the railroad, and there was scarcely a work or study related to the railroads of the Southern Pacific Company with which he did not have more or less to do, and always with credit and success. He was one of the controlling forces of that vast property.

From boyhood to his last day he remained faithful and industrious in the same employ, and it is fair to say that Mr. Curtis, more than any other, was the author of the present perfected methods and organization of the Maintenance of Way Department of the Southern Pacific Company. His duties covered thousands of miles of railroad and a wide range of climate, from the tropic heat of the Colorado Desert to the Arctic cold of winter in the Pequod Hills; from the restful scenes and orange groves of the Los Angeles Valley to the deep snows of the Sierra Nevada and Siskiyou Mountains, or from the sunny skies of the San Joaquin to the storms and floods of the Soledad and Sacramento Cañons, or the cloudbursts of the Arizona Plains. There was no time of the year when his presence might not be required on some distant portion of the property where inundation or snow impeded traffic or threatened disaster. But he was full of resources and always ready for any emergency, and in the process of time he devised expedients which have largely lessened the disastrous effects of storm and flood.

The busy life he led left him little time for recording the results of his experience, but on several occasions he prepared papers dealing with subjects to which he had devoted much thought and attention. These are most instructive, and models of brevity and careful statement.

Mr. Curtis had a wide range of knowledge and an accurate, comprehensive memory, which doubtless added to his success. It was said among his associates that he never forgot a figure.

On June 15th, 1875, at Stockton, California, he married Mary Elizabeth Burton. In her he found a fitting helpmeet. Both as son and husband he was exceptional, manifesting in his domestic life the same disposition which had made him so respected and liked by subordinates and associates. For all about him he had ever a genial

smile; for the ambitious, a word of encouragement, and for the unfortunate, one of sympathy. He never forgot the social side of life, and even on a wearisome business trip, was wont to entertain his companions with enlivening repartee and anecdote, when no affair of moment was under consideration.

Mr. Curtis was not only an engineer and manager of rare judgment, but also a clever man of affairs, outside of technical matters. His assistance and advice were often sought in other enterprises and organizations.

Two years before his death his health began to break, but with the tenacity of purpose and loyalty to his employers which had characterized his long period of service, he gave of his best until compelled to seek complete change and rest. The end came at Highland Springs, California, on the twenty-fifth anniversary of his marriage, 1900.

His loss, great as it has been to the corporation with which he was so prominently identified, was not alone a public one. It was also distinctly a private loss, and those intimately associated with him can only recall him with the poignant regret caused by the departure of one possessing all the traits of a kindly gentleman, a well-balanced citizen and a true friend.

Mr. Curtis was elected a Member of the American Society of Civil Engineers on May 3d, 1882, and served as a Director from January 15th, 1890, to January 21st, 1891. At the time of his death he was Second Vice-President of the American Railway Engineering and Maintenance of Way Association. He was also a member of the Geographical Society of California; of the San Francisco Microscopical Society; of the Technical Society of the Pacific Coast; and of the Bohemian Club of San Francisco. In the two latter societies he was formerly a Director. To all of these he gave the same careful, precise attention which he gave to his railroad duties.

RANDELL HUNT, M. Am. Soc. C. E.*

Died January 24th, 1898.

Randell Hunt was born in New Orleans, October 30th, 1856. He was graduated at Yale with degrees in engineering and philosophy. After leaving college, his first practical experience was gained in connection with the New York Public Parks.

In 1878 he established an office in Dakota, and identified himself thoroughly with the principal engineering works of the then very active and prosperous West. As a specialty, he devoted himself to bridge structures and foundations, and all through his professional career these were the particular branches in which he excelled and with which his name became prominently connected. Until 1883 he remained in Dakota, with the exception of a period in 1879, when, as hydraulic engineer, he was attached to the Mississippi River Commission, in the investigations of that great waterway.

From 1883 until 1888 he was located at St. Paul, Minn., and employed as constructing engineer by the Chicago, Burlington and Northwestern Railway. He had charge of the bridgework, and, under his direct supervision, the noted Chippewa River Bridge was built.

In 1888 he went to San Francisco and began a general engineering practice in the line of his specialty. Many of the bridges of this State were designed by him and built under his direction. In 1889 he was made the Engineering Expert of the contracting firm of Antonelle & Doe, and his name became very prominent in the controversy regarding the concrete foundations for the extensive State work on the sea wall at the foot of Market Street, in San Francisco, which caused considerable interest at the time, he contending that the system of sinking the wall by means of open floating caissons possessed innumerable advantages over the method of constructing coffer-dams for this work. He devised means for an efficient and rapid execution in this direction, and defended his position so ably that he converted the authorities to his ideas. The Harbor Commissioners finally permitted the use of this system, and the work was successfully carried out. The total length of the wall to be constructed aggregated 450 ft.; seven caissons were used, six of them 70 ft. long and one 34 ft. They were sunk in depths of from 10 ft. at low water stage to 17 ft. at high water. Only one set of sides and ends was used for the six large caissons. The sides and ends were attachable and detachable to and from the grillage forming the bottom of the structure. These designs were very interesting, and all through this extensive work

* Memoir prepared by Otto Von Geldern, M. Am. Soc. C. E.

this method of operation gave great satisfaction, for no mishap of any serious consequence occurred.

With Mr. Hunt, engineering was more than the mere means of making a livelihood. With an inborn love for his profession, he gave to every case before him a careful and deliberate study; and if he advocated his designs and upheld them with all the vigor of his energetic character, it was because he was led by an honest conviction that he contended for that which he knew to be right, and that nothing should influence him to swerve from the path which he had laid out.

In 1890 the firm of Doe & Hunt, engineering contractors, was established, and it carried on a successful business for a number of years. Here, Mr. Hunt displayed great energy and activity, and the results of his labor are manifest to-day in a great variety of existing public works. His last work under the name of the firm was the very important construction of the headworks and canal of the Turlock Irrigation District. This extensive engineering operation would have been carried to a successful completion by him had it not been for the suspension of all irrigation enterprises, by reason of legal and financial difficulties which threatened disaster to almost every irrigation district in California, the problem of recovery therefrom not having been solved to this day.

In 1897 Mr. Hunt's services were engaged by the Commission which had been charged by the Government to decide as to the respective merits of Santa Monica and San Pedro Harbors for deep-water improvement and shelter to vessels. Here he became the expert in the work of making borings in two localities, in order to establish the composition of the materials of the respective harbor bottoms. Although then suffering from a malady which proved incurable, and being very ill at the time, he carried out this trying work to the end, at a season when the conditions of the weather made it a severe test for a man in health to have been so constantly in attendance as he was.

This indomitable energy, to carry out whatever he had undertaken, was one of the principal characteristics of his nature. Physical indisposition could not incapacitate him. As long as he could be about he performed his full share of the work—and this he did to the very end of his useful life.

Socially, he was the most estimable of men. His early training and education had opened his mind to all the ennobling influences of culture and art, and, while he devoted himself to the advancement of his profession, he never lost sight of the many other elements that make up human progress. Classic literature and the literature of the day were known to him as to few others, and he delighted to converse on these subjects with those about him who enjoyed his more intimate acquaintance. He was a most genial companion, alive to every interest, kind hearted, devoted to his family and friends, and always ready to assist others in giving aid and advice.

His father, the Hon. William H. Hunt, was a very prominent man in his day. Under the administration of President Garfield he was Secretary of the Navy; after Garfield's death he was sent to Russia as Ambassador to represent the United States. He died in St. Petersburg in 1885, full of honors and mourned by two great nations.

In Randell Hunt the American Society has lost one of its most prominent members. He will be remembered, not only as an engineer of high quality, but as a man of many virtues and broad principles, who made it the maxim of his life to maintain fearlessly an honest conviction under all circumstances.

He died January 24th, 1898, after a lingering illness of several weeks.

Mr. Hunt was elected a member of the American Society of Civil Engineers, May 2d, 1883.

NILES MERIWETHER, M. Am. Soc. C. E.*

Died December 28th, 1900.

Niles Meriwether was born in Christian County, Ky., on January 26th, 1830, of parents who came of old Virginia stock, and who had gone to Kentucky in the early part of the century.

At the age of eighteen, both his parents being dead, he entered the engineering field, taking a position as a rodman on the Nashville and Chattanooga Railroad, then in process of location. He remained on this railroad, in various positions, for five years.

In 1853, he became First Assistant Engineer on the Mississippi and Tennessee Railroad (now a branch of the Illinois Central Railroad), his brother, Minor Meriwether, being Chief Engineer. In 1857, his brother resigned, and Niles became Chief Engineer, which position he held until 1862, when the occupation of Memphis by the Union Army made further railroad work impossible.

In 1865, this road being practically destroyed by the contending armies, he interested himself in securing the means to rebuild it, in which he was successful.

In 1868, he became Chief Engineer of the Memphis and Charleston Railroad (now a part of the Southern System), and held that position for eight years, during which time he built the Middleton and Ripley Branch and extended the Tullahma and McMinnville Branch to Jasper, Tenn. He also constructed most of the important bridges of this line which had been much injured during the war.

In 1875, as Chief Engineer, he took charge of the consolidated roads formerly known as the Southern and Mississippi Central, and extending from New Orleans to Cairo, Ill.

In 1877 he began the construction of the Natchez and Jackson Railroad, from Natchez to Jackson, Miss., but the yellow fever epidemic of 1878 so depleted the finances of that country that in the following winter the construction was suspended.

In February, 1879, Major Meriwether accepted the position of City Engineer of Memphis, and held this office for fourteen years, during which time he did more than any other man to restore an almost ruined city to its present prosperous condition.

In March, 1897, he took charge of the construction of a branch of the Mobile and Ohio Railroad, running from Montgomery, Ala., to Columbus, Miss., and completed the line in May, 1899. His last work was as Superintending Engineer of Elmwood Cemetery, in Memphis, which occupied his time until two weeks previous to his death.

* Memoir prepared by Mrs. M. M. Betts, of Memphis, Tenn.

During these fifty-two years of active work Major Meriwether was frequently called on to act as arbitrator or consulting engineer on many important pieces of engineering work all over the South.

He was elected a Member of the American Society of Civil Engineers on November 1st, 1871, and, at the time of his death was President of The Engineering Association of the South.

In 1855 he married Miss Lide Parker Smith, of Accomac Co., Va., and their union of forty-five years was a rarely happy one. His wife and two daughters, Dr. Lucy V. Davies, of New York, and Mrs. M. M. Betts, of Memphis, survive him and cherish his memory.

MARC JOHN REISEGER, M. Am. Soc. C. E.*

DIED MAY 26TH, 1900.

Marc J. Reiseger was born October 31st, 1861, near Groningen, The Netherlands, where he attended the public schools, going from the high school there to a college at Delft. After concluding his college career, he entered the employ of the Government as Engineer in Charge of Railroad Bridges, the railroads in that country being owned by the Government.

On May 1st, 1887, Mr. Reiseger left his native land for the United States. For a time he worked as a common laborer on the County Court House in Cheboygan, Mich., his object being to acquire a knowledge of American architecture, etc. He next went to Grand Rapids, Mich., and entered the office of a prominent architect there. In 1888 he left Grand Rapids for Muskegon, Mich., where he had been offered a similar position, which he subsequently resigned for the purpose of opening an office for himself in the same city. The business was eminently satisfactory. Among the more prominent buildings designed by him and erected under his supervision are the North Muskegon School House, the Fox Cracker Factory and the Chase Piano Factory.

In April, 1890, he took up his residence in Greenville, Mich., with the intention of engaging in manufacturing there, but in 1891 he returned to Muskegon. In 1893 he entered the United States Engineering Office in Grand Rapids, and in 1894 secured a position with Keepers and Thatcher Wynkoop, better known as the Detroit Bridge and Iron Works of Detroit, Mich., which firm subsequently became Keepers and Thatcher. While in their employ he was Engineer in charge of bridges built at Albion and Tecumseh, Mich., and Paterson, N. J. He was also for a time in the Company's office in Little Rock, Ark., on which occasion he prepared the plans for the bridge erected by them at Topeka. In April, 1899, Mr. Reiseger returned to Grand Rapids, and organized the Grand Rapids Bridge Company, of which he became President and General Manager on its incorporation, January 31st, 1900. In addition to many smaller bridges, the Grand Rapids Bridge Company built the metal-concrete bridge at Battle Creek, Mich.

Mr. Reiseger was elected a Member of the American Society of Civil Engineers on December 7th, 1898.

Early in 1900 Mr. Reiseger's health began to fail, as a result of too close application to business, and on May 26th, 1900, he died at his residence, 241 North Prospect Street, Grand Rapids, Mich., of tuberculosis-meningitis.

* Memoir prepared by Paul van Deinse, Esq.

WILLIAM HOWARD WHITE, M. Am. Soc. C. E.*

Died December 11th, 1895.

William Howard White was born in Watertown, Mass., on February 21st, 1847. He was the son of William Abijah and Harriet Tilden Sturgis White. His father's sister, Maria, was the first wife of James Russell Lowell. Mr. White's father and mother died when he was a little boy, and he was taken into the family of and brought up by Mrs. Francis George Shaw, his mother's sister.

In July, 1865, Mr. White was graduated from the Lawrence Scientific School, Harvard University, in the course of civil engineering (*magna cum laude*), and then commenced practice as a civil engineer, in which profession he distinguished himself with great honor.

His first engineering work was in connection with the sewerage of New York City, from August 9th, 1865, to January 10th, 1867. He then became engineer in charge of the construction of seven miles of the Sullivan and Erie Railroad, in Pennsylvania, until March 14th, 1868.

From May 13th, 1868, to March 31st, 1870, he was an Assistant Engineer on the Burlington and Missouri River Railroad. From 1870 to 1873, as Assistant to Colonel Mendell, U. S. Engineers, he worked on the original survey of San Pedro Harbor. The following year he spent in Europe, studying foreign engineering and languages.

Mr. White afterward became Chief Engineer of the New York and New England Railroad System, covering about 450 miles. During 1879–1883 he was Assistant Chief Engineer of the Chicago, Burlington and Quincy Railroad, having charge of all the engineering work on the Iowa lines, embracing some 900 miles.

At the end of this period Mr. White again went to Europe, where he spent two years in studying foreign sanitary engineering and appliances.

For seven years following 1885 he was a Consulting Engineer in New York City with a branch office in Chicago. Some of the clients by whom he was consulted were Messrs. Brown Brothers & Company, of New York; Carey & Whitridge, attorneys for an English investment company, and Messrs. Morton, Bliss & Company, of New York. On the strength of reports made by him the Pillsbury & Washburn Mills, at Minneapolis, having an aggregate capacity of 20 000 bbls. of flour per day, were purchased, and action taken on properties in Kentucky aggregating $5 000 000 in value.

Mr. White was elected a Member of the American Society of Civil Engineers on March 5th, 1873, and served as a Director for the year 1886.

In 1878 Mr. White was married to Margaret Howard Parker, of New

* Memoir prepared by W. A. Nicholls, M. Am. Soc. C. E.

York City, and in the fall of 1892 they went to Redlands, Cal., from South Orange, N. J., with their three children, seeking a milder climate for the benefit of Mr. White's failing health. Some months previous to this Mr. White had visited Redlands and purchased 24 acres of orange lands, and here he built a home.

He was a man of great intellectual force, and always prominently identified himself with the best interests of the community in which he resided. He died in Redlands, December 11th, 1895.

His last professional work was the giving of expert testimony, from the bed from which he never was to arise, before a Commission, appointed for the purpose by the Superior Court, in a suit involving important questions in water development near Redlands.

Mr. White presented several valuable papers before the Society, and was a frequent contributor to the discussions.

JOSEPH RUGGLES RICHARDS, Assoc. Am. Soc. C. E.*

Died September 28th, 1900.

Joseph Ruggles Richards, oldest child of Wyatt Richards (born at Hardwick, Mass., March 8th, 1802, died in Boston, February 9th, 1872), and Sarah Page Ruggles (born at Roxbury, Mass., June 9th, 1796, married April 5th, 1827, died in Boston, March 17th, 1878), was born at 63 Myrtle St., Boston, February 18th, 1828.

He obtained his education in the public schools of Boston, passing through the various grades of the Mayhew School, on Chardon St., and, finally, being graduated from the English High School in the year 1845, winning one of the six Franklin Medals for scholarship. He was especially good in mathematics, a taste which followed him all through his professional life; nothing pleasing him more than to work up a truss or difficult problem in construction, or to figure out the dimension figures on a set of plans, working for an hour at a time to find the missing inch to tie a column of figures. When he had finished, one was sure the figures were correct. His natural taste for drawing is shown in the many drawings he made when a boy.

His expense accounts, carefully kept from youth up, bear witness to his businesslike methods.

Under the date of October 6th, 1845, he records:

"I, J. R. Richards, this day entered the office of Mr. Gridley J. F. Bryant, 4 Court Street (Boston), for the purpose of serving my apprenticeship under him in the Architectural profession. Seventeen years old on the 18th day of February, 1845."

At the end of the first year he began to receive regular pay, in ever increasing amounts as the half years went by, turning also many an honest penny by over work, writing, translating French, and odd work on his own account.

The many embryo architects who worked with him under Mr. Bryant, then one of the most active and influential architects in the country, will bear witness to Mr. Richards' faithfulness and ability, and tell with admiration of the amount of work he could "throw off."

The systematic time cards or diaries he kept show where each hour was spent; and the number and variety of the works he undertook is remarkable.

On January 1st, 1853, he opened an office on his own account at 46 Court St., corner of Tremont St., Boston, in a building famous from the names of Washington and Lafayette associated with it, and famous later for having Daniel Webster as a tenant.

* Memoir prepared by William P. Richards, Esq., Boston, Mass.

In July, 1865, the firm of Richards and Park was formed by the admission of William S. Park, his brother-in-law. The firm was dissolved in 1872, Mr. Richards continuing the business alone.

On October 1st, 1880, he admitted his son William P. Richards into partnership with himself, ending it only with his death on September 28th, 1900.

His list of clients contains the names of many honored people, and his work, though principally confined to the neighboring States, extended to New York, Pennsylvania, Louisiana, Alabama, California, Wisconsin, Kansas, Florida and Minnesota.

The City of Boston early employed him, and for a number of years he designed for it schools, engine-houses, armories, stables and other structures.

The State of Massachusetts also appears early, as a client, and at intervals up to a recent date. At one time he made plans for work on the State House, and at another he was one of the Commissioners on extensive alterations to it, executed for them by Mr. G. J. F. Bryant.

The State Capitol at Montpelier, Vt., was erected under his supervision, the drawings of another architect being handed to him to carry out and finish, and in 1885–86 he designed and executed an annex to this building for the Supreme Court and State Library.

Harvard, Amherst Agricultural, Dartmouth, Williams and Hamilton Colleges, also Baker University, Kansas, appear on his books; and he erected important buildings for them.

The cities of Cambridge, Brookline, Lowell, Woburn, Blackstone, Mass., and Kenosha, Wis., employed him on schools and various public works.

The counties of Suffolk and Franklin each had their Court Houses enlarged and remodelled by him.

A stone church in Greenfield and a brick church in Taunton show his ability, as also brick and stone libraries in West Brookfield, Greenfield, Sudbury (the latter again enlarged in 1894), the Waverly House, in Charlestown, and the Crawford House, in Boston.

Numerous large stores and business blocks, and town, city and summer houses in Boston and neighboring towns were planned and carried out by him.

Among his more recent and larger works are the "Jarvis" and "Stanstead" apartment houses in Cambridge, "White" apartment house, Commonwealth Ave., Boston, Five Cents Savings Bank Building in Woburn, Royal Arcanum Building, Boston, and Colored Odd Fellows' Building, Boston.

Throughout his entire practice it had been his custom to lay out and do most of the important office and outside work himself; his draughtsmen, in consequence, few in number, doing what he could not accomplish in the busy days.

Of him *The American Architect and Building News* speaks, as one:

"Whose unfailing courtesy and interest in artistic matters had made him for many years a favorite in the profession. Although his works belong rather to the last generation than to this, he carried out in his younger days very many mercantile and other buildings, characterized by a quiet good taste which was then perhaps the best quality that such architecture could show."

Outdoor sketching in pencil and water color was a constant pleasure to him, and his leisure moments in the office were often taken up in working with his brush. A large collection of pictures and studies give evidence of a remarkable taste and talent for water-color painting.

As the years passed he gradually left more and more of the office work and outside duties to the younger partner, but, without fail, except when sickness prevented, and that rarely, would come to the office and attend to his duties.

At the close of office hours, except for rare occasions, home was the next object in view, and, arrived there, it would again be a rare occasion, as time went by, for him to spend the evening away, though he was peculiarly sociable in his temperament and enjoyed the company of his friends. Masonic cares occupied his time early in his career, but he gradually dropped the active cares and attendance at meetings. He was admitted to Amicable Lodge, Cambridgeport, in August, 1856; St. Paul's Royal Arch Chapter, in 1859, and Boston Commandery, Knights Templars, in 1860.

He was married to Mary A. Phillips of South Natick, Mass., daughter of Thomas and Clarissa Brackett Phillips, on August 27th, 1851, and commenced housekeeping in Cambridge, where he watched the gradual building up of residences, schools and library on the acres of vacant land near him. To reach his Boston office, he profited by the slow change from omnibus to horse car, and from horse to electric car, the first horse cars from Cambridge passing his door. The Fitchburg Railroad had a branch track almost to Harvard Square, now discontinued, which he used on first coming to Cambridge.

His wife and daughter and one of two sons survive him.

As a referee, he acted acceptably in a number of cases, and as executor or administrator he settled up several estates successfully and happily. As Trustee for the North End Savings Bank for a number of years, he rarely lost a meeting with his co-trustees, and his advice on investments in real estate was invaluable.

Though actively interested in the political life of the town and State, and never failing to go to the polls to vote, he never accepted public office.

On May 22d, 1867, he attended the first meeting called by the architects of Boston for the purpose of forming a Society of Architects, and on September 3d he was elected a Fellow Member, which membership he

kept up until his death. He was a loyal member to that Society and his fellow architects, was ever ready to help it or them, and his fairly regular presence at the monthly meetings of the Society will be missed.

He was elected an Associate of the American Society of Civil Engineers on February 4th, 1880, and, though distance from New York prevented him from taking an active interest in all the meetings, he looked forward with pleasure to the Annual Meetings and Annual Conventions which make up a large part of the social life of the Society, and, when he could, joined these gatherings.

JOHN MONTGOMERY TOUCEY, F. Am. Soc. C. E.*

Died September 29th, 1898.

John Montgomery Toucey was born in Newtown, Conn., on July 30th, 1829. He prepared for Trinity College, but, finding that his tastes did not lie in the direction of the ministry, he took up the profession of teaching. After pursuing that profession for two years, he began railroad work as a station agent at Plymouth, now Thomaston, on the line of the Naugatuck Railroad, then in process of construction.

Soon after, he was placed in charge of the construction of the railroad between Waterbury and Winsted—heavy freshets having severely damaged it—and was highly commended for the rapidity with which the work was carried out under his direction. He was married in 1851, and secured employment with the Madison and Indianapolis Railroad, and, subsequently, as a freight agent on the Morris and Essex Railroad. In the spring of 1855 he entered the service of the Hudson River Railroad Company, as a passenger conductor, and afterward became its agent at East Albany. In 1862, Samuel Sloan, then President of the road, appointed him Trainmaster, and so well were his duties performed that he was appointed Assistant Superintendent in 1867.

In the same year he resigned, to accept the office of General Superintendent of the Delaware, Lackawanna and Western Railroad, but retained the office only two months, as he was recalled to the Hudson River Railroad and made its General Superintendent in full charge of the line. He continued in charge of this section of the road after the consolidation with the New York Central in 1869, and in 1881 his authority was extended over the lines west of Albany. In February, 1890, the office of General Manager was created for Mr. Toucey, and this office he held until it was abolished, eight years later, after the election of Mr. Callaway as President. A month later he presented his resignation, and was placed on the retired list at half-pay.

For forty-three years Mr. Toucey was a responsible officer of the New York Central and Hudson River Railroad. He was a man of great energy and resolution, his dominant trait being unwearying fidelity; and he had, in particular, the gift of managing trains and moving passengers and traffic expeditiously and at minimum cost. He was bold in assuming responsibility, but had a keen desire to learn what was best in the practice of others. In his personal relations with the employees of the railroad, he was genial and sympathetic, and the older men in the service were strongly attached to him

* Memoir prepared by the Secretary from papers on file at the House of the Society.

on account of his friendly interest in their associations, his unostentatious charity, and his management of the Christmas dinners provided for the men.

The railroads of the United States are indebted to Mr. Toucey for many improvements. He was first to introduce interlocking switches in the United States. These were placed in the Grand Central Yard. The present circular form of scoop for taking water for locomotives from a tank between the tracks is due to his experiments at Montrose in conjunction with Mr. Wm. Buchanan. He was Manager of the Grand Central Station at the time the entire system of tracks was changed at that locality, and proposed and urged the abolition of the crossings at grade.

At the World's Congress of Railways, in London in 1895, as a result of the profound impression made by Mr. Toucey's remarks, with regard to the speed of the Empire State Express, several representatives of the continental lines have inspected the track of the New York Central, and have made reports to their companies confirming Mr. Toucey's statements. At the Congress Mr. Toucey was accorded great respect as a representative American railroad man.

Mr. Toucey wrote little besides his personal and official correspondence, seldom spoke in public, and was reluctant to appear in conspicuous positions. His personality, therefore, was known to comparatively few, save those with whom he had business relations. He had taken little rest from active work since his first engagement in his boyhood, and he suffered from illness for several months before his death.

Mr. Toucey became a Fellow of the American Society of Civil Engineers on May 17th, 1870.

Rensselaer Polytechnic Institute,
Troy, N.Y.

ESTABLISHED 1824.
A SCHOOL OF ENGINEERING

Local examinations provided for. Send for a Catalogue

LOUISVILLE CEMENT.

The undersigned is General Agent for the following Standard Brands of Louisville Cement:

FALLS MILLS (J. Hulme Brand),
BLACK DIAMOND MILLS (River), Diamond Brand,
SPEED MILLS, Star Brand,
FALLS CITY MILLS, Anchor Brand,
BLACK DIAMOND MILLS (Railroad), Diamond Brand.

This Cement has been in general use throughout the West and South since 1830; most of the public works having been constructed with it. Orders for shipment to any part of the country, by rail or water, will receive prompt and careful attention.

Sales for 1892: 2,145,568 Barrels.

WESTERN CEMENT COMPANY,
247 W. Main St., Louisville, Ky.

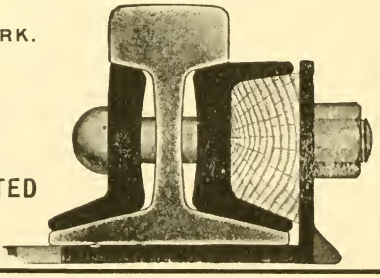
THE WEBER RAILWAY JOINT MFG. CO.

EMPIRE BUILDING,
71 BROADWAY, NEW YORK.

BRANCHES:
BOSTON, MASON BLDG.
CHICAGO, OLD COLONY BLDG.
BALTIMORE, EQUITABLE BLDG.

—o—

Manufacturers of
"T" STEP and INSULATED
JOINTS.



ESTABLISHED 1845.

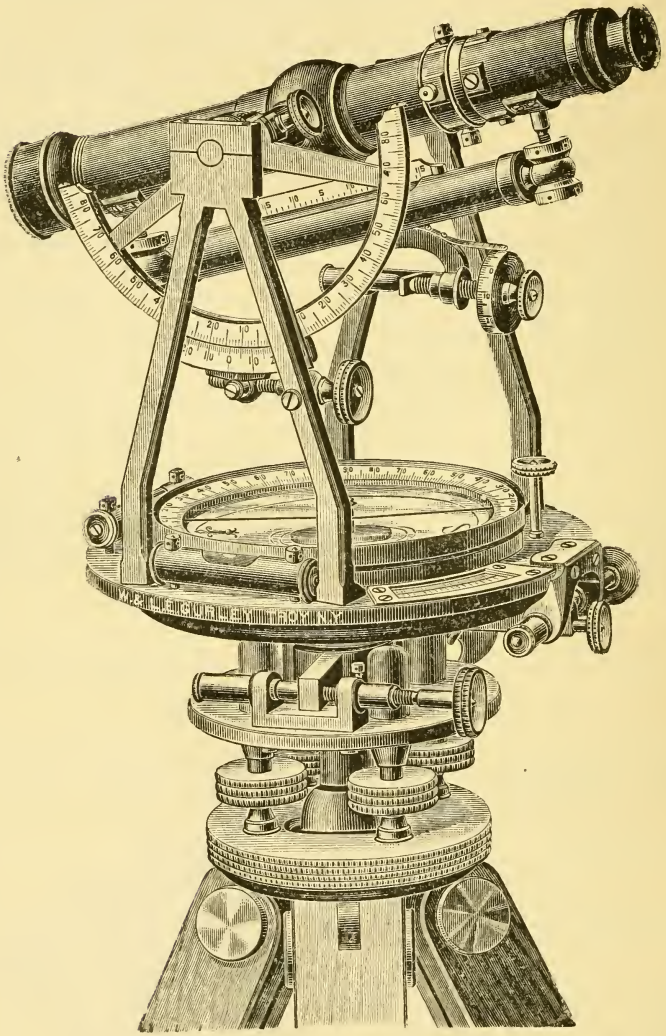
W. & L. E. GURLEY

TROY, N. Y., U. S. A.

LARGEST MANUFACTURERS IN AMERICA OF

Civil Engineers' and Surveyors' Field Instruments.

TRANSITS, LEVELS, COMPASSES, PLANE TABLES, CURRENT METERS.

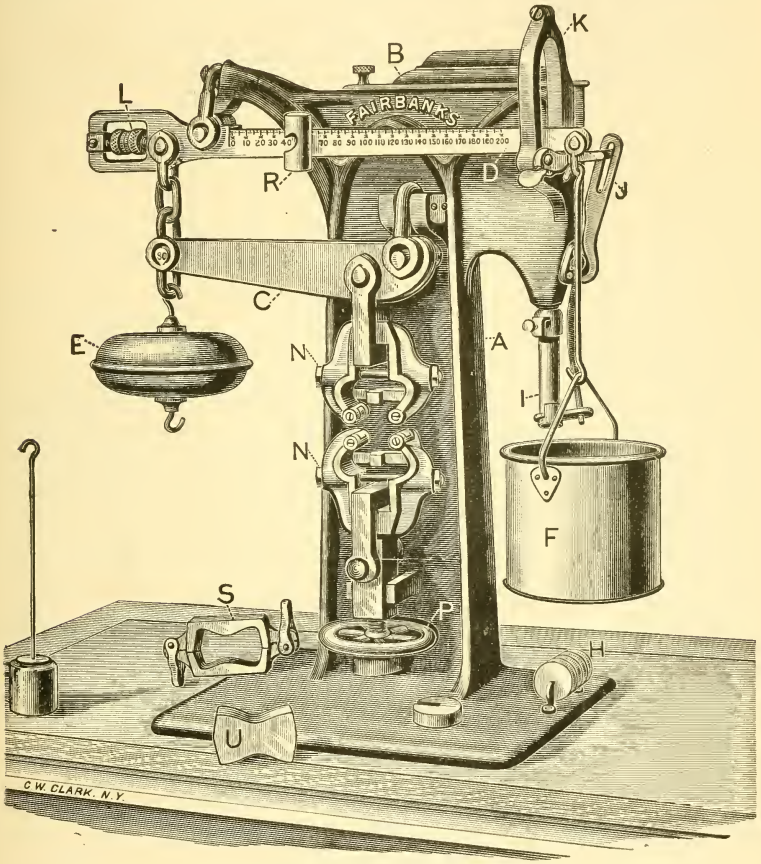


LEVELING RODS, CHAINS, TAPE LINES, ANEMOMETERS, BAROMETERS, ODOMETERS.

LATEST CATALOGUE MAILED ON APPLICATION.

FAIRBANKS'

PATENT AUTOMATIC CEMENT TESTING MACHINES.



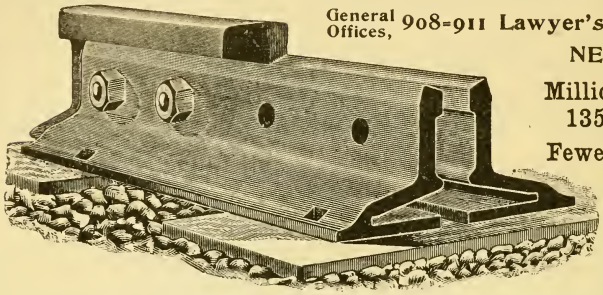
Descriptive Circular of Machines and Appliances, with Prices, Forwarded on Application.

The Fairbanks Company,

311 BROADWAY, NEW YORK.

ALBANY, N. Y.; BALTIMORE, Md.; BUFFALO, N. Y.;
BOSTON, Mass.; PHILADELPHIA, Pa.; PITTSBURG, Pa.; NEW ORLEANS, La.;
MONTREAL, Que.; LONDON, England.

CONTINUOUS RAIL JOINT CO. of AM.



General Offices, 908-911 Lawyer's Building, NEWARK, N. J.

Millions in use on 135 Railroads.

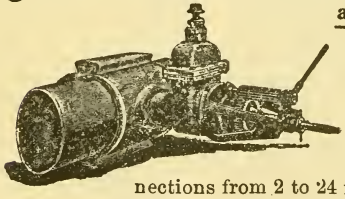
Fewest parts possible. Provides for the increased tonnage up to date.

BEST ECONOMICAL RESULTS.

GIANT PORTLAND,
EGYPT PORTLAND,
IMPROVED UNION,
AND UNION CEMENTS.

MANUFACTURED BY
AMERICAN CEMENT CO., Egypt, Pa.,
LESLEY & TRINKLE, Sales Agents,
22 & 24 South 15th St., Philadelphia.

Connecting Branch Sleeve and Tapping Apparatus



For making Large Connections without Shutting Off Water or Reducing Pressure.

This is no experiment, but has been used by the Water Departments of numerous cities for years with entire success. Connections from 2 to 24 ins. have been made with mains from 4 to 48 ins. For full information, address

THE A. P. SMITH MFG. CO., 921 Prudential Building, Newark, N. J.

The Evening Post Job Printing House,

FULTON STREET, CORNER BROADWAY,

NEW YORK.

PRINTERS OF PERIODICALS.

ALCATRAZ ASPHALT

Guaranteed free from Coal Tar or Petroleum Residuum,

For Reservoir Linings

and Pipe Coatings.

The Alcatraz Co.

General Offices: Bryson Block, Los Angeles, Cal.,
and Crocker Building, San Francisco, Cal.

ATLANTIC, GULF AND PACIFIC CO.

Hydraulic Dredge discharging through 5,700 ft. of pipe.

ENGINEERS AND CONTRACTORS

Geo. W. CATT, M. Am. Soc. C. E., M. Inst. C. E., Pres. & Eng. THOS. J. LONG, M. Am. Soc. C. E., Vice Pres. & Engr.
H. S. WOOD, C. E., Sec. & Treas. H. KRUSI, C.E., Pac. Coast Man. R. A. PERRY, Supt

SPECIALTIES: Dredging, Dredging Machines, Land Reclamation, Docks, Piers, Foundations, Bridges.
Correspondence solicited.

MAIN OFFICE: PARK ROW BUILDING, NEW YORK.
PACIFIC COAST OFFICE: 220 MARKET STREET, SAN FRANCISCO, CAL.

WEST PASCAGOULA CREOSOTE WORKS,

WEST PASCAGOULA, MISS.

Situated on Pascagoula Bay and on the line of the Louisville and Nashville Railroad.

These works have been in operation for more than twenty years, were recently entirely rebuilt and enlarged, and are now prepared to execute all orders for creosoted piles and timber thoroughly impregnated with dead oil of coal tar.

New cylinders 115 feet long. Capacity, one million feet per month.

Address S. W. LABROT,
SUPT. WEST PASCAGOULA CREOSOTE WORKS,
West Pascagoula, Miss.

15,000,000 BARRELS

"HOFFMAN" CEMENT

Have been used on important works throughout the United States.

NO OTHER CEMENT COMPANY CAN SHOW SUCH A RECORD.

"DRAGON" PORTLAND

Specified by Architects and Engineers since 1889 on National, Municipal and Railroad Improvements.

Sales Office, No. 1 Broadway, New York.
Philadelphia Office, Harrison Building, 15th and Market Sts.

THE LAWRENCE CEMENT COMPANY.

E. R. ACKERMAN, PRES.

ASSOC. AM. SOC. C. E.

ESTABLISHED 1856.

Warren Foundry and Machine Co.

WORKS AT PHILLIPSBURG, NEW JERSEY.

SALES OFFICE: 160 BROADWAY, NEW YORK.

CAST-IRON, WATER AND GAS PIPE,

FROM 3 TO 48 INCHES DIAMETER.

Also all sizes of FLANGED PIPE and SPECIAL CASTINGS.

THE F. O. NORTON COMPANY,

—MANUFACTURER OF—

Hydraulic Cement,

92 BROADWAY, NEW YORK.

Particularly adapted for work under water, for which use it is superior to the best Portland Cement, when used 1 to 1.

Certificates of tests and reports on actual use in important public works furnished on application.

OUR LEADING

Architects, Engineers and Builders

SPECIFY AND USE

BROOKLYN BRIDGE BRAND

ROSENDALE HYDRAULIC CEMENT.

USED EXCLUSIVELY ON { PARK ROW OFFICE BUILDING—30 STORIES. WALDORF-ASTORIA HOTEL—LARGEST IN THE WORLD.

HAVE SUPPLIED FOR NEW YORK CROTON AQUEDUCT, IN 1897 AND 1898, 165,000 BARRELS.

ATLAS Portland Cement

IS THE STANDARD AMERICAN PORTLAND.

The U. S. Government gives it preference over all other brands.

ATLAS PORTLAND CEMENT CO.,

143 LIBERTY STREET, NEW YORK CITY.

IRONCLAD PORTLAND CEMENT

Manufactured by GLENS FALLS PORTLAND CEMENT CO.

Sole Selling Agent, **Commercial Wood & Cement Co.,**

156 FIFTH AVENUE, NEW YORK.

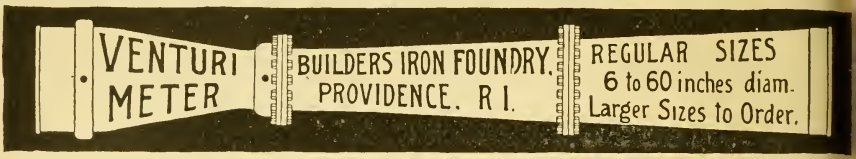
High-grade American PORTLAND CEMENT unsurpassed for making Fine Artificial Stone.

LABORATORIES OF Dr. CHAS. F. McKENNA, 221 PEARL ST., NEW YORK.

Successor to Dr. GIDEON E. MOORE.

DEPARTMENT OF CHEMISTRY. Analyses and Assays of Ores, Metals, Waters and Natural and Industrial Products of every description.

DEPARTMENT OF PHYSICAL TESTS. Tensile, Transverse and Compression Tests of Iron, Steel and other Metals and Alloys, Cements, Building Stones and Engineering Materials generally.



THE VENTURI METER is the only practical meter for measuring large quantities of water.

ITS ACCURACY is unquestioned and it is frequently employed to test the accuracy of pumps.

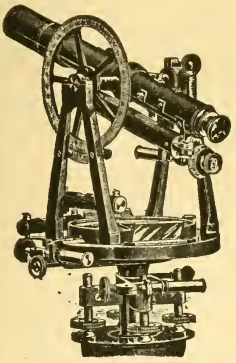
NO BY-PASS is necessary, and the cost of tees, elbows and gate-valve is avoided.

Otis Elevator Company.

HYDRAULIC,
ELECTRIC AND
STEAM ELEVATORS

For Passengers and Freight.

NEW YORK, BOSTON,
CHICAGO, PITTSBURG,
PHILADELPHIA, SAN FRANCISCO.



ESTABLISHED 1872.

F. E. BRANDIS SONS & CO.,

MANUFACTURERS OF

Engineers' and Surveyors' Instruments,

814 GATES AVENUE,

BROOKLYN, NEW YORK.

Catalogues mailed on application.

THE RAND DRILL COMPANY,

Pioneers in Rock Drilling and Air Compressing Machinery,

128 BROADWAY, NEW YORK,

HAS BEEN AWARDED

THREE GOLD MEDALS

AT THE

PARIS EXPOSITION

For AIR COMPRESSORS and ROCK DRILLS.

Eppinger & Russell Co.,

CREOSOTING WORKS,

Dead Oil of Coal Tar Process.

Piles and Timber treated with the above Oil for all purposes, when preservation is desired.

Introduced in England by Mr. Bethel in 1838. **DEAD OIL OF COAL TAR** is the only known product of commercial application that will preserve **TIMBER FROM DECAY, LAND AND MARINE INSECTS.**

Our Mr. Valentine has had practical experience since 1872, and we have specimens of Piles and Timber treated by him in 1874, which are in use to-day and are in a perfect state of preservation. **We have the largest and best equipped plant in the world. Cylinders 100 ft. long, capacity 1,500,000 ft. per month.**

Direct Water and Rail Communications.

MANUFACTURERS OF THE

Valentine Electrical Subway Conduit.

WORKS:
Foot First Street and Newtown Creek,
LONG ISLAND CITY.

OFFICES:
MORRIS BUILDING
66 BROAD ST., NEW YORK.

SEND FOR CIRCULARS AND PRICES.

The Brown Hoisting Machinery Co.,

INCORPORATED,

Engineers, Designers and Manufacturers of Special Machinery for the Economical Handling of COAL AND ORE.

BRIDGE TRAMWAY UNLOADERS for Discharging Bulk Cargoes from Vessels to Cars or Storage on Dock.

FAST PLANT UNLOADERS, for Handling Bulk or Package Freight.

CRANES of Every Type.

Main Office and Works, CLEVELAND, OHIO, U. S. A.

NEW YORK. PITTSBURG. LONDON.

EXTENT OF ASPHALT PAVEMENTS

IN THE UNITED STATES AND CANADA.

Trinidad Lake Asphalt Pavement, 21,527,415 square yards, or 90%

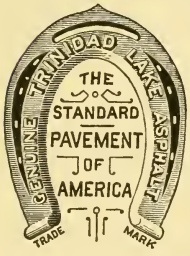
Other kinds Asphalt Pavement, 2,307,064 square yards, or 10%

OF THE TRINIDAD LAKE ASPHALT PAVEMENT

10,000,000 square yards, or nearly 50%,

WAS LAID BY

THE BARBER ASPHALT PAVING COMPANY.



This is equal to about 650 miles of Roadway, 26 feet wide.

The Asphalt used by this Company is from the famous Pitch Lake in the Island of Trinidad, B. W. I.

Plans and Estimates Furnished on Application.

GENERAL OFFICES:

LE DROIT BUILDING, - - - WASHINGTON, D. C.

BOWLING GREEN BUILDING, No. 11 Broadway, New York.

F. V. GREENE, President.

SUPERIOR GRAPHITE PAINT

For BRIDGES, ROOFS, . STRUCTURAL IRON, ...

And all Exposed Metal or Wood Surfaces.

Warranted not affected by heat, cold, salt brine, acid fumes, smoke or chemicals. . . . . .

Detroit Graphite Mfg. Co.,

DETROIT, MICH.

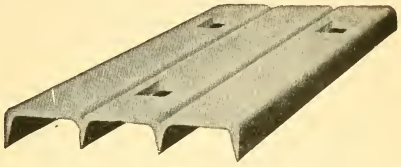
THE

Q & W Tie Plate

ALTHOUGH SOMETHING NEW,

Has a Record, from the fact that it is a combination of the

SERVIS AND WOLHAUPTER PLATES.....



THE Q AND C

CHICAGO:
700-712 Western Union Building.
NEW YORK:
106 Liberty Street.
SAN FRANCISCO:
537 Mission Street.

PROCEEDINGS

OF THE

AMERICAN SOCIETY OF CIVIL ENGINEERS.

SELECT ADVERTISEMENTS WILL BE RECEIVED AT THE FOLLOWING RATES:

	ONE YEAR. 10 INSERTIONS.	½ YEAR. 5 INSERTIONS.	3 INSERTIONS.
One Page.....	$170 00	$95 00	$60 00
One-half Page.....	90 00	55 00	35 00
One-quarter Page	50 00	30 00	20 00
One-twelfth Page, Card	20 00	.....	.....

Address the Secretary of the Society, 220 West 57th Street, New York.

THE

AMERICAN BRIDGE COMPANY

DESIGNERS AND
BUILDERS OF . .

Steel Bridges, Steel Buildings

AND ALL CLASSES OF

Metallic Structures.

OFFICES:

100 BROADWAY, NEW YORK.

7339 190

MISSING

VOLUME 27

ISSUE# 4-10

MONTH Apr-Nov

YEAR 1901

NORTHEASTERN UNIVERSITY LIBRARIES
3 9358 00841453 1

NORTHEASTERN UNIVERSITY LIBRARIES
3 9358 00841453 1